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EARTH-WORMS AND THEIR WONDERFUL WORKS.*

By W. H. LARRABEE.

THE subject of Mr. Darwin's latest volume is the share which worms have taken in the formation of the layer of vegetable mold that covers the surface of the land in every moderately humid country. It is a real surprise to learn, from the observations which Mr. Darwin has so patiently made for nearly half a century, and which he records in this work, how important a part these unconsidered creatures have played in giving to the surface of the land its generally fine consistency and fertile properties, and how essentially and vastly they have contributed to the comfort and prosperity of mankind. Ever since his first paper on vegetable mold was read before the Geological Society of London, in 1837, Mr. Darwin has kept on with his investigations, in flower-pots in his room, in his garden, and in the field, and has detected the work of the worms wherever anything will grow—in meadows and table-lands, in cultivated places and in woods, on mountains fifteen hundred feet high in Scotland, nearly twice as high at Turin, seven thousand feet above the sea on the Nilgiri Hills of Southern India, and on the slopes of the Himalayas—effecting the transformation of the hard, cold earth, and the raw leaves into fine, fruitful soil. It is easy to say, as some have done, that the creatures are too insignificant to accomplish so extensive a work; but the facts adduced by Mr. Darwin convey a striking lesson in the principle that nothing is so minute that it can be despised.

We may first consider the agent apparently so insignificant that has done so much to transform and clothe the surface of the earth.

* The Formation of Vegetable Mold through the Action of Worms, with Observations on their Habits. By Charles Darwin, LL. D., F. R. S. With Illustrations. Published by D. Appleton & Co., New York.

Lumbricus is the name of the best-known genus, of which the species have not been accurately distinguished and numbered; but only a part of them bring up earth in the form of castings, and are engaged in making tillable soil. They appear to be found wherever there is moist earth containing vegetable matter, but seem to abound most where the ground is loose and well charged with humus. Dryness is unfavorable and even fatal to them; but, although they are terrestrial animals, they have been found by M. Perrier to be capable of living for a considerable time under water. During the summer, when the ground is dry, and during the winter, when it is frozen, they penetrate to a considerable depth in the earth and cease to work. They are nocturnal in their habits, and may be often seen at night crawling over the ground, more often moving their heads and bodies around while their tails are still inserted in their burrows. Only sickly worms, such as are afflicted by the parasitic larva of a fly, as a rule travel in the day-time; and those which are seen dead on the ground after heavy rains are supposed to have been creatures afflicted in some way that have died of weakness rather than by drowning. They often lie quite still close beneath the mouths of their burrows, where their heads may be seen on looking for them, and, in this position, offer a tempting bait to birds.

FIG. 1.—DIAGRAM OF THE ALIMENTARY CANAL OF AN EARTH-WORM (*Lumbricus*), (copied from Ray Lankester in "Quarterly Journal of Microscopical Society," vol. xv, new series, pl. vii).

The body of a large worm consists of one or two hundred almost cylindrical rings or segments, each furnished with minute bristles, and is endowed with a well-developed muscular system. The mouth is provided with a little projection or lip, capable of taking hold of things, and of sucking. Internally, a strong pharynx, corresponding, according to Perrier, with the protrusile trunk or proboscis of other annelids, and which is pushed forward when the animal eats, is situated behind the mouth. The pharynx leads into the œsophagus, on each side of the lower part of which are three pairs of large glands, which secrete a surprising amount of carbonate of lime. They are unlike anything that is known in any other animal, and their use is largely a matter of speculation. Mr. Darwin thinks they are partly excretions of the excess of lime contained in the leaves which the animal eats, and that they otherwise aid digestion by affording a neutralizing agent against the acids of its food. In most of the species the œsophagus is enlarged into a cup in front of

the gizzard. The latter organ is lined with a smooth, thick, chitinous membrane, and is surrounded by weak longitudinal but powerful transverse muscles. Grains of sand and small stones, from one twentieth to a little more than one tenth of an inch in diameter, may be found in the gizzard and intestines, and are supposed to serve, like millstones, to triturate the food. The gizzard opens into the intestine, which presents a peculiar remarkable longitudinal involution of the walls, by which an extensive absorbent surface is gained. The circulatory system is well developed. Breathing is done by the skin, without special respiratory organs. The nervous system is fairly developed, with two almost confluent cerebral ganglia situated near the anterior end.

Worms have no eyes, and are measurably indifferent to light ; yet they can distinguish night from day, and are quickly affected by a strong light, and after some time by a moderate light shining continuously upon them. They do not much mind a moderate radiant heat, but are sensitive to cold. They have no sense of hearing, but are extremely sensitive to vibrations in any solid object. Worms in pots, which had paid no attention to the sound of a piano, when placed on the piano instantly drew into their holes when the notes were struck. Their whole body is sensitive to contact, as of a puff of air. Their sense of smell is feeble, but responds fairly well to the odor of the cabbage and onion or whatever they like, as was shown to Mr. Darwin by some very interesting experiments. They are omnivorous, and swallow enormous quantities of earth, out of which they extract any digestible matter which it may contain, consume decayed and fresh leaves and vegetable matter, and raw, roasted, and decayed meat, but like raw fat best.

Mr. Darwin discovered in worms evidences of a degree of intelligence. They line their burrows with leaves as a protection, it is supposed, against the cold of the clammy ground, and plug the entrances to them with leaves and leaf-stalks. It requires some manipulation to get these leaves in right, but the worms know how to perform it, and can discriminate between the easiest way to draw the leaf in and other ways. Commonly, seventy or eighty per cent of the leaves are drawn in by the tips, that being the direction in which they go in most easily and fold most nicely. Some leaves, however, may be drawn in nearly as easily by the sides or the bases as by the tips, and a larger proportion of these are drawn in in those ways. The worm likes to gnaw the base of the petiole of the ash-leaf, and this leaf is drawn in by the base. Pine-leaves, which grow in pairs attached to a single base, must be drawn in by the base or not at all, and the worm rarely makes a mistake in the matter. Mr. Darwin suggests here, however, that we must not suppose the worm to know too much, and that some other quality than mechanical convenience may guide it to the selection of the base of the pine-leaf. Sometimes, when the worm begins to plug

its hole, it drags leaf-stalks in by the base so as to fill it faster; but as soon as it comes to close quarters, it turns and drags the rest of the stalks in by the tips. Triangles of paper were given worms instead of leaves, and they likewise drew them in in the easiest way, apparently at the first trial. When worms can not obtain leaves, petioles, sticks, etc., with which to plug up the mouths of their burrows, they often protect them by little heaps of stones; and such heaps of smooth, rounded pebbles may frequently be seen in gravel-walks. A lady interested in this study removed the little heaps of stones from the mouths of several burrows, and cleared the surface of the ground for some inches all around. She went out on the following night with a lantern, and saw the worms, with their tails fixed in their burrows, dragging the stones inward by the aid of their mouths. After two nights some of the holes had eight or nine small stones over them; after four nights one burrow had about thirty and another thirty-four stones, and one of the stones weighed two ounces. The strength of worms is also shown by their often displacing stones in a well-trodden gravel-walk, a task that sometimes demands considerable effort.

Worms excavate their burrows in two ways: by pushing away the earth on all sides where the ground is loose or only moderately compact, and where they are able to disappear from sight with surprising agility; and by swallowing the dirt, where the ground is hard, and ejecting the swallowed earth afterward in the form of the "castings" which are found at the mouths of their burrows. Worms also swallow earth to extract the nutritous matter which may be contained in it, and in larger quantity than for making their burrows; and the residue of this, after the nutriment is extracted, is also cast out. The deposition of castings, then, is no insignificant part of the labor that they perform, and leaves very perceptible traces upon the surface. The castings may be seen by any one who will take the pains to look for them, and often in garden-walks without looking for them, piled up in the shape of towers of greater or less height around the burrows. The towers formed by a naturalized East Indian worm, at Nice, France, which are sometimes distributed as thickly as five or six to a square foot, are built to a height of from two and a half to three inches. The tower of a *perichæta* in the Botanic Garden at Calcutta, of which Fig. 2 is an exact representation, measured three and a half inches high and 1·35 inch in diameter. One tower from Calcutta was five inches high and two and a half inches in diameter; and the average weight of twenty-two castings sent Mr. Darwin from Calcutta was an ounce and a quarter. The largest castings mentioned came from the Nilgiri Hills in South India, seven thousand feet above the sea, and afforded one specimen that weighed a quarter of a pound, the largest convolutions of which were about an inch in diameter. The manner of forming the casting is described by Mr. Darwin: "A worm after swallowing earth, whether for making its

burrow or for food, soon comes to the surface to empty its body. The ejected earth is thoroughly mingled with the intestinal secretions, and is thus rendered viscid. After being dried it sets hard. I have watched worms during the act of ejection, and when the earth was in a very liquid state it was ejected in little spurts, and when not so liquid by a slow, peristaltic movement. It is not cast indifferently on any side, but with some care, first on one and then on another side, the tail being used almost like a trowel. As soon as a little heap is formed the worm apparently avoids, for the sake of safety, protruding its tail, and the earthy matter is forced up through the previously deposited soft mass." Some of the towers, as the figure shows, exhibit a considerable degree of skill in their construction. The castings are not always ejected on the surface of the ground, but are often lodged in any cavity that may be met in burrowing. The burrows run down, sometimes perpendicularly, generally a little obliquely, to a depth of three, six, and even eight feet, and are usually lined with a thin layer or plaster of fine, dark-colored earth which the animals have voided, in addition to which a lining is made, near the mouths, of leaves, also plastered. Bits of stones and seeds are also sometimes found in the bottom of the burrows, having been taken down apparently with a purpose.

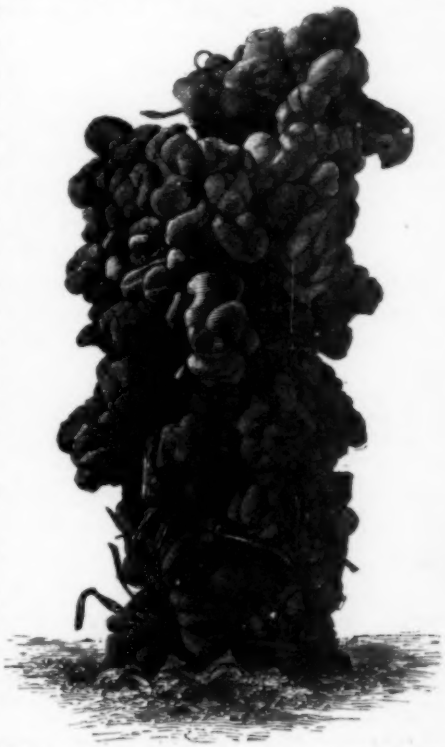


FIG. 2.—A TOWER-LIKE CASTING, PROBABLY EJECTED BY A SPECIES OF PERICHÆTA (from the Botanic Garden, Calcutta: of natural size, engraved from a photograph).

The amount of earth brought up by worms from beneath the surface has been carefully estimated by observing the rate at which stones and other scattered objects on top of the ground are buried. A piece of waste, swampy land, which was inclosed, drained, plowed, harrowed, and thickly covered with burned marl and cinders, and sowed with grass, in 1822, fifteen years afterward, presented the appearance, where holes were dug into it, shown by Fig. 3, the scale of which is half that of nature. Beneath a sod an inch and a half thick was a layer of vegetable mold, free from fragments of every kind, two and a half inches thick. Under this was another layer of mold, an inch and a half thick,

full of fragments of burned marl, conspicuous from their red color, fragments of coal-cinders, and a few white-quartz pebbles. Beneath this layer, and at a depth of four and a half inches from the surface, the original black, peaty, sandy soil with a few quartz pebbles was

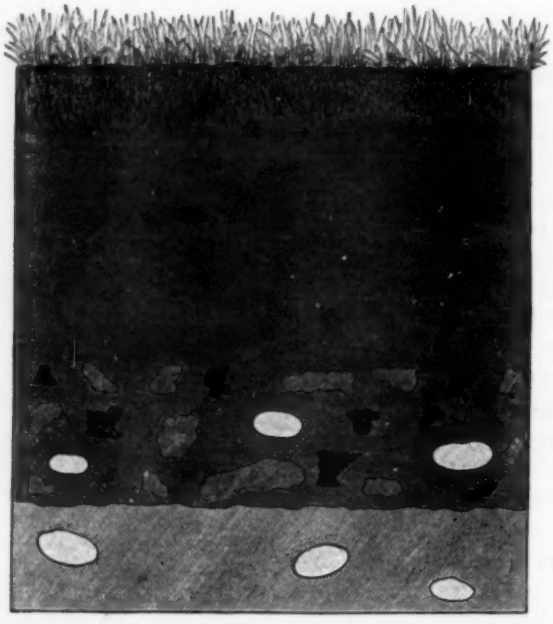


FIG. 3.—SECTION, REDUCED TO HALF THE NATURAL SCALE, OF THE VEGETABLE MOLD IN A FIELD, DRAINED AND RECLAIMED FIFTEEN YEARS PREVIOUSLY. A, turf; B, vegetable mold without any stones; C, mold with fragments of burned marl, coal-cinders, and quartz-pebbles; D, sub-soil of black, peaty sand, with quartz-pebbles.

encountered. "Here, therefore," says Mr. Darwin, "the fragments of burned marl and cinders had been covered in the course of fifteen years by a layer of vegetable mold, only two and a half inches in thickness, excluding the turf." Six and a half years afterward this field was re-examined, and the fragments were found at from four to five inches beneath the surface, having been covered in that time with an inch and a half more of mold. The average annual increase of thickness for the whole period was ·19 of an inch. This was less than the average increase of thickness in some other fields similarly observed, in which the accumulation amounted to ·21 and ·22 of an inch annually.

Another field, lying upon the chalk, and sloping rather steeply in one part, which was turned into pasture-land in 1841, was for several years so thickly covered with small and large flints that Mr. Darwin's sons always called it "the stony field." When they ran down the slope the stones clattered together; and Mr. Darwin remembers doubting whether he should live to see the larger flints covered with vegetable

mold and turf. But the smaller stones disappeared before many years had elapsed, as did every one of the larger ones after a time; so that after thirty years, or in 1871, a horse could gallop over the compact turf from one end of the field to the other, and not strike a single stone with his shoes. This, says Mr. Darwin, "was certainly the work of the worms, for, though castings were not frequent for several years, yet some were thrown up month after month, and these gradually increased in numbers as the pasture improved." The accumulation of mold was, however, of the slowest, measuring only .083 of an inch a year. A flagged path in Mr. Darwin's garden disappeared in the course of years, it might be said under his very eyes, the worms covering it with an inch of mold.

A stone, sixty-four inches long, seventeen inches broad, and from nine to ten inches thick, part of the ruins of a lime-kiln that had been torn down thirty-five years before, lay in a field, its base sunk from one to two inches below the general level, while the surface of the field for about nine inches around it sloped up toward it to the height of four inches above the surrounding ground close to the stone. The stone could not have sunk by its weight, and there was evidence that one of its pointed ends, the upper surface of which was now on a level with the surrounding turf, must have stood clear of the ground for several inches. The situation of the stone is represented in Fig. 4.

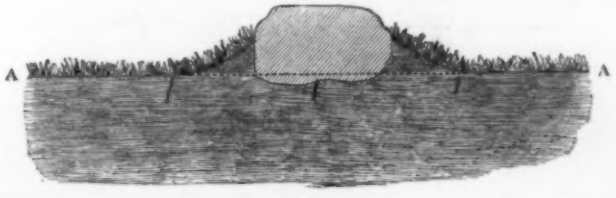


FIG. 4.—TRANSVERSE SECTION ACROSS A LARGE STONE WHICH HAD LAIN ON A GRASS-FIELD FOR THIRTY-FIVE YEARS. A A, general level of the field. The underlying brick rubbish has not been represented. Scale one half inch to one foot.

When the stone was removed, an exact cast of its lower side, forming a shallow crateriform hollow, was left, the inner surface of which, except where the base had been in contact with brick rubbish, consisted of fine black mold. The turf-covered border, which sloped up to the stone, consisted of fine vegetable mold, in one part seven inches thick, and was evidently derived from worm-castings, several of which had been recently ejected. This stone would have sunk to the level of the field in two hundred and forty-seven years if none of the castings were washed away by rains.

Some of the fallen stones at Stonehenge have become buried to a moderate depth in the ground, and are surrounded by sloping borders of turf, on which recent castings were seen. In the case of the stone represented in the cut (Fig. 5), which is by no means the most marked specimen, the turf-covered border sloped on one side to the height of

four inches, and on the other side of two and a half inches, above the general level.

Thus, evidence is gathered that small objects left on the surface of the land where worms abound soon get buried, and that large stones

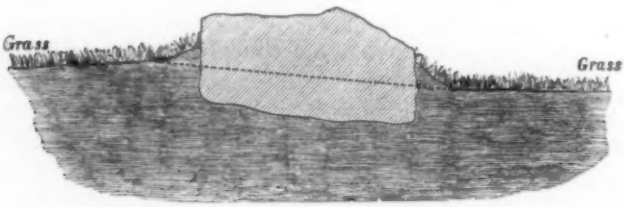


FIG. 5.—SECTION THROUGH ONE OF THE FALLEN DRUIDICAL STONES AT STONEHENGE, SHOWING HOW MUCH IT HAD SUNK INTO THE GROUND. Scale one half inch to one foot.

sink slowly downward by the same means. Every step of the process could be followed. Among the most striking features of the case are the straightness and regularity of the lines formed by the imbedded objects in cases where they have covered a considerable surface, and their parallelism with the surface of the land, for this parallelism shows how equally the worms must have worked. The specific gravity of the objects does not affect their rate of sinking, as could be seen by porous cinders, burned marl, chalk, and quartz pebbles having all sunk to the same depth within the same time; and many considerations seem to show that the sinking could not have been sensibly aided by the weight of the objects.

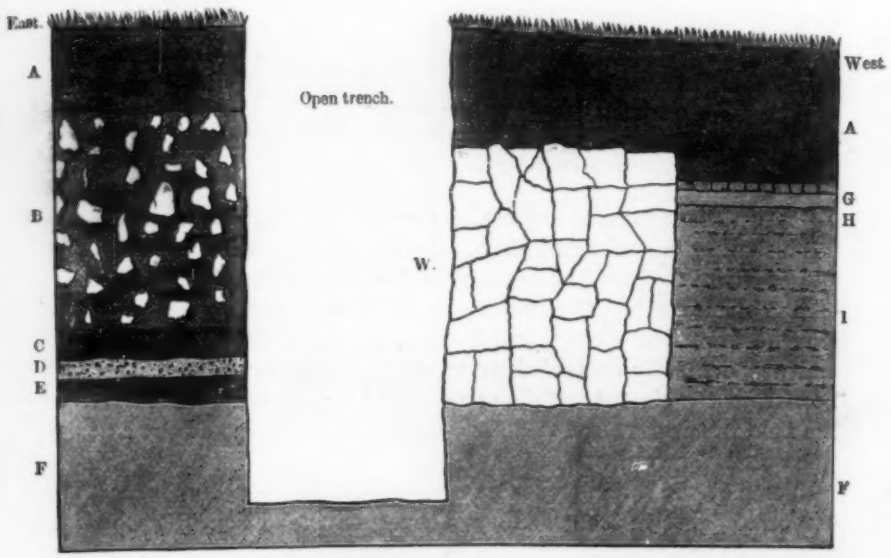


FIG. 6.—SECTION THROUGH THE FOUNDATIONS OF A BURIED ROMAN VILLA AT ABINGER. A A, vegetable mold; B, dark earth full of stones, thirteen inches in thickness; C, black mold; D, broken mortar; E, black mold; F F, undisturbed sub-soil; G, tesseræ; H, concrete; I, nature unknown; W, buried wall.

The estimates of the amount of mold brought up by the worms, based on actual weighings and measurements of the castings at particular spots, give results ranging from 7·56 to 18·12 tons per acre in one year, and a volume sufficient to make when spread out a layer of soil of from one to more than two inches thick in ten years.

"Archæologists," says Mr. Darwin, "are probably not aware how much they owe to worms for the preservation of many ancient objects. Coins, gold ornaments, stone implements, etc., if dropped on the surface of the ground, will infallibly be buried by the castings of worms in a few years, and will thus be safely preserved until the land at some future time is turned up." The remains of ancient buildings seem also to have been buried effectively, in large part, through the action of worms. An example of this kind is furnished at Abinger, Surrey, where the remains of an ancient Roman villa were discovered in 1877. The cut (Fig. 6) represents the appearance presented by the buried wall and the ground around it at a point where one of the trenches was dug. The mold here was from eleven to sixteen inches thick over the tesselated floor, G, and from thirteen to fifteen inches thick over the broken summit of the wall, W. No signs of worms appeared on the trodden-down earth over the *tesseræ* when they were first cleared, but many signs of fresh worm-action were seen on the next day, and for the next seven weeks these signs were very abundant. Numerous burrows were also found in the course of the digging, and worms were brought up from a considerable depth. Three years afterward the worms were still at work, burrowing in the concrete floor and the mortar of the walls, as they had probably been doing ever since

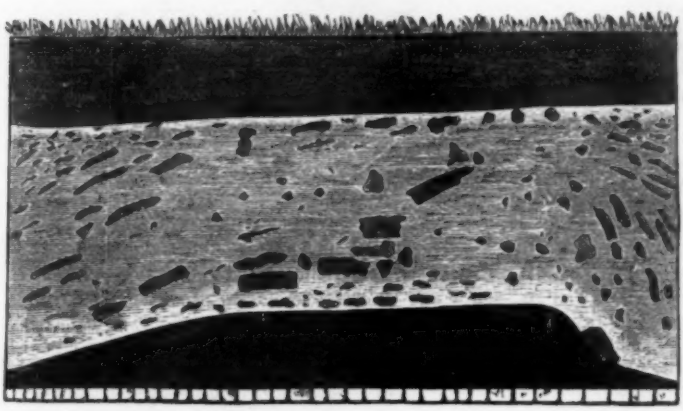


FIG. 7.—SECTION WITHIN A ROOM IN THE BASILICA AT SILCHESTER. Scale $\frac{1}{48}$.

the concrete had become decayed enough to allow them to penetrate it; and even before that period they probably lived under the floor, making burrows which, collapsing from time to time, helped make the walls and floor sink.

Other striking examples of the action of worms are found in the ruins of the old Roman town of Silchester, of which Figs. 7 and 8 show the extent to which the basilica has been covered. In Fig. 7, the concrete floor, still covered here and there with *tesseræ*, is found at three feet below the surface, and on it are piles of charred wood, represented by the black. Fig. 8 does not reach to the natural subsoil. Worm-castings were observed on the floors of several of the rooms, in one of which the tesselation was unusually perfect. One or

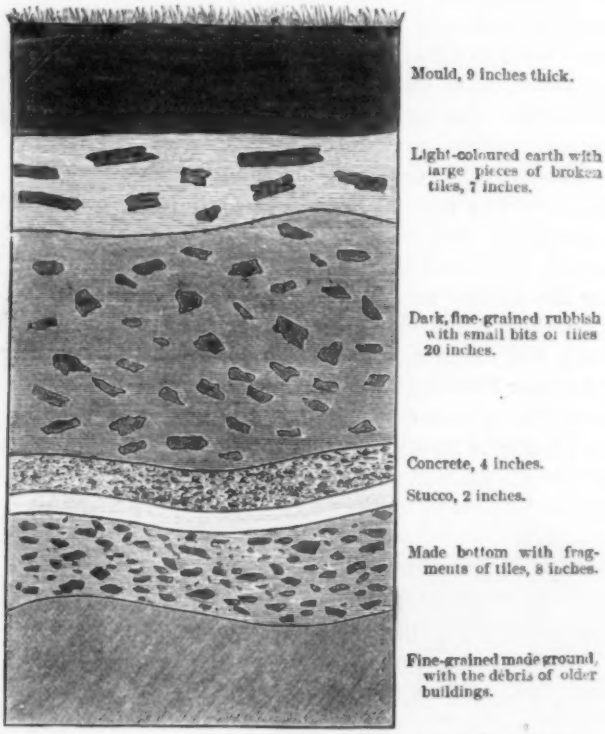

Mould, 9 inches thick.
Light-coloured earth with large pieces of broken tiles, 7 inches.
Dark, fine-grained rubbish with small bits of tiles 20 inches.
Concrete, 4 inches.
Stucco, 2 inches.
Made bottom with fragments of tiles, 8 inches.
Fine-grained made ground, with the débris of older buildings.

FIG. 8.—SECTION IN THE CENTER OF THE BASILICA AT SILCHESTER.

occasionally two open worm-burrows were found beneath all the loose *tesseræ*. Worms have also penetrated the old walls of the ruins, and were found in them, with traces of the mold which they had carried to them. In almost all the rooms the pavement has sunk considerably, as Mr. Darwin shows in three sections, one of which he gives (Fig. 9). Dust blown by the wind and earth washed from the hills may have partly aided in covering up these buildings, but the chief share of the work is attributable to worms.

Worms also contribute to the disintegration of the rocks and the denudation of the land, by generating humus acids which act on the carbonates, by grinding up in their crops the stones they swallow, and

by bringing earth to the surface in their castings, to be blown away by the winds and washed away by the rains into the valleys. They are extraordinarily numerous. Hensen says there are 53,767 of them in an acre of garden-soil, and Mr. Darwin is willing to allow half that number, or 26,886, to the acre in corn-fields and pasture-lands; and as in many parts of England a weight of more than ten tons of dry earth annually passes through their bodies and is brought to the surface on each acre, the whole superficial bed of vegetable mold must pass through them every few years. By triturating this earth, by subjecting its minerals to the action of the humus acids, and by periodically exposing the mold to the air, they prepare the ground in an excellent manner for the growth of fibrous-rooted plants and for seedlings. The bones of dead animals, the harder parts of insects, the shells of land-mollusks, leaves, twigs, etc., are before long all buried beneath the accumulated castings of worms, and are thus brought in a more or less decayed state within reach of the roots of plants. Leaves are digested by them and converted into humus. Their burrows, penetrating to a depth of five or six feet, are believed to aid materially in the drainage and ventilation of the ground. They also facilitate the downward passage of roots of moderate size, which are nourished by the humus with which the burrows are lined. Many seeds owe their germination to having been covered by castings; others, buried more deeply, lie dormant till they are brought under conditions favorable to germination. "The plow," says Mr. Darwin, in conclusion, "is one of the most ancient and most valuable of man's inventions; but long before he existed the land was in fact regularly plowed, and still continues to be thus plowed, by earth-worms. It may be doubted whether there are many other animals

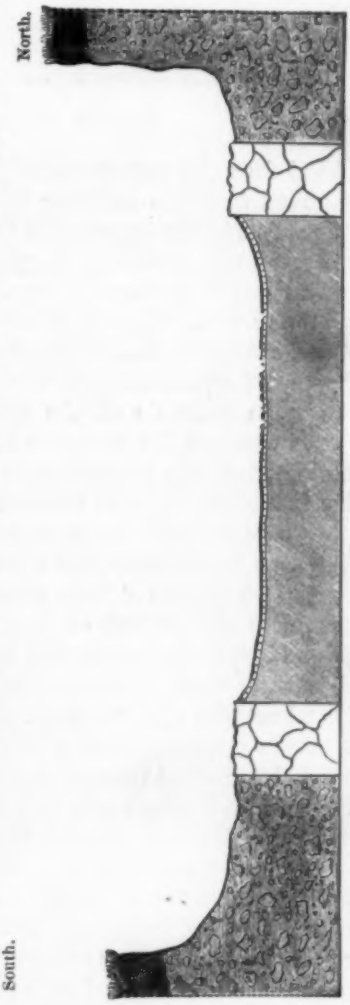


FIG. 9.—A NORTH AND SOUTH SECTION THROUGH THE SUBSIDED FLOOR OF A CORRIDOR PAVED WITH TESSERÆ. Outside the broken-down bounding walls, the excavated ground on each side is shown for a short space. Nature of the ground beneath the tesseræ unknown. Silchester. Scale, ¼.

which have played so important a part in the history of the world as have these lowly-organized creatures." The coral animal is their most conspicuous rival in this claim.

ASTRONOMY IN HIGH-SCHOOLS.

By MISS ELIZA A. BOWEN.

I HAVE for some years been much interested in trying to introduce improved scientific teaching into girls' schools; and I propose to tell the result of some experiences in teaching astronomy.

Of course, the astronomy taught has been of the most elementary character. But it is therefore exactly the foundation which it is important to lay well. My object has been to gain for my pupils from this study, not merely knowledge, but all the mental discipline it could afford. In order to accomplish this, I have made it an invariable principle to make them do all the *observing*, all the *thinking*, possible. They have watched the heavenly bodies to discover their appearance and motions, and then I led them on to discuss the causes. It has been genuine inductive study, so far as it has gone. My own work seemed very simple; but it occasioned me a great deal of observation, thought, and study. I have simply *kept them on the track*.

It may at first seem a little absurd to talk of a set of school-girls treading, with any degree of mental independence, the path which Kepler and Tycho Brahe found it so difficult to walk in. Of course, it would be utter nonsense to say that they could exercise anything like the mental activity of those great men. But there are various degrees of the mind's activity, and it is possible to arouse, even in school-girls, a very wholesome and improving amount of it.

When I first began, I merely intended to make some girls of seventeen years old, who were soon to study Lockyer's "Astronomy," do some preparatory observing. I soon saw that it would have been desirable to begin earlier; and, in the room in which I talked to these young ladies, there were seated at desks some young girls of thirteen and fourteen years old, who listened to my talk and directions with great interest, and, as I soon found, were observing and thinking with as much energy as their older companions. It became out of the question to refuse instruction to those who showed themselves so capable of learning. All the work of which I am about to tell was well performed by girls of fourteen years old.

The method I tried can best be understood by one or two illustrations. I will first say, briefly, that they found for themselves the chief stars in nearly every important constellation by drawings I made on the blackboard or on bits of paper (aided by my hectograph). As

soon as they learned the Dippers in Ursa Major and Ursa Minor, and Cassiopeia, I put them to making observations at an interval of several hours on the same night, so as to find out the daily apparent motion. Thus far they knew Polaris only as "the star in the handle of the Little Dipper." It was some days before all reported observation, and I did not indorse any report until we had full concurrent testimony that from 6 P. M. to 12 the Great Dipper moved down toward the horizon and then east (it was autumn), that Cassiopeia moved up and then west, and that the bowl of the Little Dipper had turned on the handle until it was nearly upside down. They drew the Little Dipper on the blackboard, and made arrows to indicate the direction in which the other constellations moved. They remarked, without prompting, that the arrows made a kind of circle. After another night's observation, the report was brought that at 6 P. M. the constellations had returned to the positions occupied by them at 6 P. M. of the previous day. They said the stars must have gone entirely round that star in the handle of the Dipper, or else have moved backward. By this time the interest had become so great that a number of girls rose before day to take a look; so we had a further report. When they had settled as fully as they could the fact of the apparent motion, I asked them, "When an object seems to move, does it always prove to be in motion?" Many cited in answer the apparent motion of the trees when one journeys by rail. After drawing from them the fact that the real and the apparent motions are always in opposite directions, I asked, "Do you think the earth is turning round, or are the stars moving round it?" Up to this time several intelligent girls had been without suspicion that they were coming round to the familiar fact of the earth's rotation on its axis, learned from the beginning of their geographies. Their surprise, when my question flashed this result on them, was very amusing. It was to me a striking illustration of the inadequacy of learning things about nature from books alone.

I will not weary the reader with an account of the observations which detected the apparent annual motion of the stars, and the facts and questions which led them to conclude that it resulted from a real motion of the earth, in a circle, with the sun in the center. They also detected the apparent motion of the sun north and south, and had a very interesting discussion whether this was real or apparent. In the course of this study, they experimented in a darkened room with a light, and a ball revolving on its axis. The ball was held at the solstitial and equinoctial positions, and revolved, and they drew the conclusions regarding length of days. The work was just as much as possible their own.

One of the most interesting studies made by my pupils was that of the moon. They began with the new moon, and of course very soon accounted for its daily apparent motion west. Then they watched the real motion from night to night. I must not forget to say that regu-

lar books were kept by them for recording observations. They kept account of the phases and the corresponding relative positions of the sun, moon, and earth. This led to a very interesting discussion as to what makes the moon shine. In the course of this, they drew diagrams and experimented with the ball and light. They detected the earth-shine, and settled its cause for themselves; found out that the moon moves round the earth, and noted the time; noted the hours of rising; noted the various constellations through which the moon takes its path; and noted the effect of their situation on the moon's time of rising. After these points had been settled, I asked them, had they ever seen the moon show more than one face. As this called attention to the fact that the moon always shows (substantially) the same face, the cause was discussed. To settle it, a girl stood in the middle of the room and another walked round, facing her all the time. They finally settled for themselves that the moon revolves once on its axis while it moves once round the earth. I gave them no further help than the question I have just stated. I have not yet had pupils trace the moon's path and that of the sun so accurately as to discover the nodes, but I certainly shall try to do so, and to have the retrograde motion of the nodes detected; the time (approximate) of their revolution. I shall pass over nothing that ordinary eyes can see, ordinary minds reason out.

The study of planets affords delightful work. Some of my pupils have studied Mercury with great interest, finding that his orbit is within that of the earth and of Venus; finding the direction of his motion round the sun, and the period. The study of Mars is in the highest degree profitable, and so is that of Venus. The young folks can readily discover the retrograde motions, and, with the simple suggestion that the apparent retrograde may result from the changed position from which we view the planet, may find the relative positions and detect the cause.

I occasionally report to my young astronomers a little of the testimony of other persons. Thus, in discussing the cause of the moon's light, I told them of stars occulted by the dark part of the moon. In doing so, I always wait until they have exhausted the evidence of their own senses; and I am specially careful to distinguish between the two kinds of testimony. It leads, with older girls, into some very interesting discussions as to the value of other people's evidence.

Sometimes some of the girls begin to *guess*. I always take special care (in a good-natured way) that guessers shall come to shame. I endeavor to make them as accurate as possible, allowing the evidence to prove just what it ought, and no more.

My pupils have been so much interested in astronomy, that their talk about it has brought to me a good many persons who wish to sell me some sort of apparatus for illustrating the motions of the solar system or some part of it. I do not much believe in these contriv-

ances. They are very apt to take the place of the observation of nature, a very pernicious result. Besides, to understand the motions, one must study each separately. The observation of nature must precede the illustration of nature. A light and a ball revolving on its axis sometimes help. The very simplest apparatus is the best. Young folks have a superstition about complicated apparatus. It begets a vague wonderment which is very far removed from a scientific temper. God's own great machinery is undoubtedly the thing to study. But a small telescope would enlarge greatly the field of observation. The pupils could, with its aid, study Jupiter's miniature system, the rings of Saturn, the phases of Venus and Mercury; and, by the sun-spots, they could detect the revolution of the sun on his axis. Mr. Whitall, of Phillipsburg, New Jersey, gets up a small telescope for fifty dollars which would be of great use. I find the astronomers who wish to do original work have great contempt for a telescope costing less than eight hundred dollars. Mr. Whitall's telescope is probably better than that which discovered Jupiter's moons and Saturn's rings, and, for the sort of teaching I have described, would do a great deal of good.

I have a good deal of trouble with people who are attracted by the interest of my girls, and who always want to tell them the things they ought to find out for themselves. Bright young fellows from college, who want to show off before the girls, are particularly given to this. But my pupils themselves aid me, for they do not wish to be told.

It is important to have a good deal of drawing. Fortunately, in the best schools, the importance of this art is now appreciated. The constellations should be drawn from nature and from memory, with a statement on each map of the boundaries. When any planet is under study, I always have diagrams drawn showing its various positions in relation to the sun and the earth.

I do not pretend that this is other than the most elementary work, and I do not myself pretend to be much of an astronomer.

There is nothing wonderful in teaching as I have described, but it is certainly a great mistake to teach otherwise. It is probable that, in the active centers of thought, others have adopted this plan. It is certainly far from general. I am sure nearly all teachers of girls would find their own knowledge made more accurate by the observation and study it requires. Teachers in boarding-schools, who are with their pupils at night, could accomplish admirable results; and I should think intelligent parents would be delighted to train their own children.

TIME-KEEPING IN PARIS.

By EDMUND A. ENGLER,
WASHINGTON UNIVERSITY, ST. LOUIS.

MANY of the discoveries of science which at the time are regarded merely as refinements—very interesting, but without practical value—sooner or later find their special uses in supplying wants before unfelt. It is but one of the evidences of the advance of civilization that exact methods of dividing and measuring time are now in demand, not only by scientists and professional men as formerly, but by persons in the most ordinary pursuits of life. To railroad-men and watch-makers as a matter of necessity, to manufacturers and business-men as a matter of economy, and to individuals as a matter of convenience, it has come to be highly important to know what is the exact time of day to the second, in circumstances where half a century ago it would have quite sufficed to know the minute or even the hour. This may be due to the increased value of time when measured by the number of events or the magnitude of operations which modern ingenuity is capable of crowding into a given interval; there can be no doubt that a second to-day records a greater stride in the world's progress than did many hours in the days of our ancestors. Of so great importance, for many evident reasons, has the knowledge of the exact time become, that much thought of some of the best heads has been devoted to methods of ascertaining it and making it available by distribution for public use.

The methods of obtaining the exact time by astronomical observations have long been well established, and are, except in minor details, the same in all parts of the world. It will here be sufficient to say, in explanation of the usual method, that time is determined by observing the transit, over the meridian, of stars—or other heavenly bodies—whose position is known by previous calculation verified by repeated observation. The difference between the time of the calculated meridian passage and the time indicated by the clock when the star was observed to pass the meridian is the error of the clock. The face-reading of the clock at the instant of transit corrected for this error is the exact time at that instant.*

* It is, perhaps, needless to say that the operation of taking time by the transit instrument is really far more complicated than would appear from the description above; but the difficulties arise only from mechanical or physical imperfections, or from uncertain or changing conditions. Thus, corrections must always be made in nice work for errors in the instrument or its setting—such as the level, azimuth, and collimation corrections—for personal equation of the observer, and for aberration; these corrections, however, only aid the observer in ascertaining the exact instant when the star actually crossed his meridian and do not in any way affect the principle already given. For a full account of the methods of making these corrections, the reader is referred to Chauvenet's "Astronomy."

But experience has shown that no clock, however fine its mechanism, will run without change of error; so that, although for a particular instant the error of a clock is known by astronomical observation, it is by no means certain what will be its error for any subsequent instant. Its error for this instant can be determined with precision only by another observation. An approximation to its error at any instant can, however, be obtained by simple calculation, based upon two assumptions: first, that the change in error between the last two (or any previous two) observations was uniformly distributed over the interval of time between those observations, thus making it possible to determine a rate of change; second, that the rate of change in error since the last observation has been uniformly the same as during the previous interval. The reliability of this approximation is evidently entirely dependent upon an empirical knowledge of the clock. Cloudy weather sometimes makes this method the only resource.

In order that a clock should be used as an indicator of time, it is not enough that its error at every instant should be known; its error must be continually corrected so that its face-reading shall always indicate true time. And, in order that a clock should be used as a distributor of time, it must be provided with apparatus, distinct from the mechanism which keeps the time and in no way interfering with it, which is capable of sending time to other clocks. The methods and instruments in use in Paris for the accomplishment of these two objects will be described in this paper.

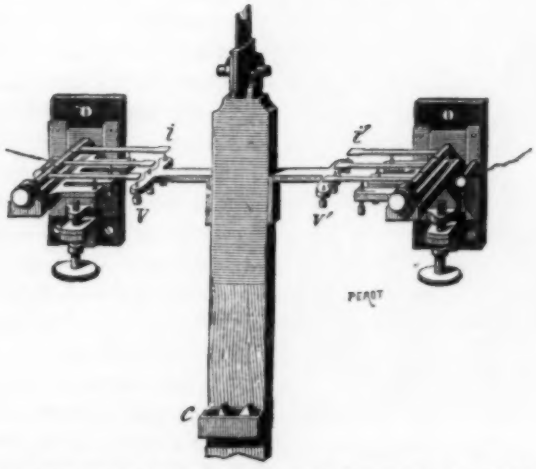


FIG. 1.—REGULATOR OF PARIS OBSERVATORY—PENDULUM CONTACT-PLATES.

At the Paris Observatory a very fine standard clock or astronomical regulator is kept running on correct mean time by transit observations, being provided with the most approved self-compensating

apparatus, and being further corrected daily by the adjustment of weights to the pendulum. For the latter purpose the pendulum-rod is provided with a box, *c* (Fig. 1), for holding small weights; these are made of such shape that they can be easily put into the box or taken out by means of a small pair of pincers without in any way affecting the running of the clock. The box being placed above the center of oscillation of the pendulum, the addition of a weight makes the clock go faster and the removal of a weight retards it. By repeated experiment it has been ascertained what change each weight, under given conditions of atmospheric influences, will produce in a given time; so that the operator knows how to adjust the weights in every case, and the clock can be kept running on mean time with the greatest attainable accuracy.

This clock, beating seconds, closes for, say, one half second during each vibration an electric circuit along the line of which the secondary clocks are situated. This is done by means of the apparatus shown at the top of Fig. 1. To the upper end of the pendulum-rod are attached arms, *V* and *V'*, which alternately raise the levers, *i* and *i'*, as the pendulum vibrates, thus closing the contact of the electric circuit, one wire of which reaches the arms *V* and *V'*, while the other is attached to the levers *i* and *i'*. There are three levers at *i* and *i'*, and three contact points on the arms *V* and *V'*, in order that the transmission of the current need not depend upon a single contact which some trivial circumstance—as, for example, the lodging of a grain of dust—might prevent.

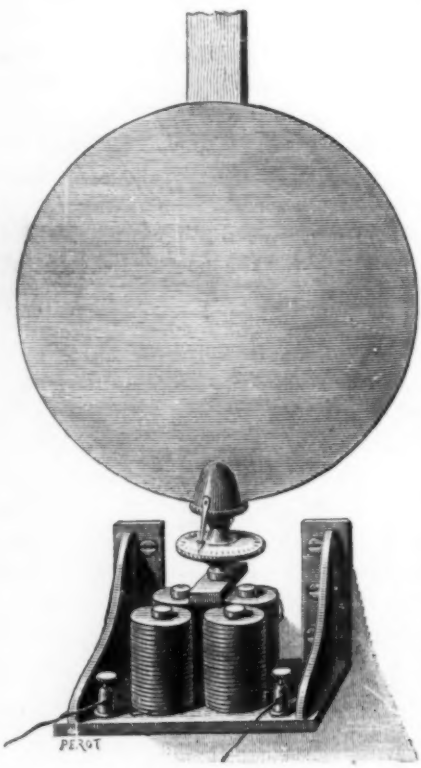


FIG. 2.—PENDULUM OF SECONDARY CLOCK.

The current thus transmitted is carried along wires placed in the city drains to the secondary clocks, which are controlled by the regulator at the observatory, as shown in Fig. 2; but the motive-power of each is a weight operating as in ordinary clocks. To the foot of the pendulum of each secondary clock is attached a piece of soft iron, which swings just above the poles of two electro-magnets in the

circuit of the observatory clock. The operation is as follows: The secondary clocks are kept running with a very small gaining rate. At each vibration of the pendulum of the observatory clock the circuit is closed, and a current passes from a battery of six Daniell cells and magnetizes one of the electro-magnets at the foot of the pendulum of each secondary clock, which, attracting the piece of soft iron, retards its motion. The adjustment is delicately made, so that the retardation is just sufficient to keep the secondary clocks beating synchronously with the observatory clock.

This system, in Paris the device of M. Breguet, is a modification of the Jones system, which is considered by scientists the best ever invented for regulating clocks at a distance from the standard clock. Its main advantage lies in the fact that by no disaster to the wire of the circuit or to the regulator of the system can the secondary clocks be stopped. Should, by any accident, the wire be broken or the observatory clock stopped, the secondary clocks move right on, only slightly too fast; whereas, in any system of dials which are driven by a standard clock, any such mishap must of necessity stop the dials, whereby those depending upon them for time are misled, if not entirely deprived of time. In point of accuracy the results in this system are indeed all that could be desired, the error of the secondary clocks being kept less than one tenth of a second; but, because the secondary clocks must be fine time-keepers, the system is quite expensive. The estimated cost of each of these clocks is from 2,400 to 2,500 francs, or from $480 to $500. On the two circuits, each terminating at both ends at the Observatory of Paris, there are distributed thirteen clocks, the farthest being at a distance of seven and a half kilometres, or nearly four and a half miles from the observatory. The clocks are furnished with second-hands, and are placed so that they can be easily seen from the street, and usually in prominent positions. The system is entirely under municipal management and has been in successful operation for about four years.

But the system thus far described is the basis of a much wider distribution of accurate time; for each of the secondary clocks is itself provided with apparatus, by means of which it sends a signal every hour to clocks placed on special circuits and to the public clocks of the city. For this reason the secondary clocks have come to be known as "horary centers." The methods employed for the distribution of the hourly signals from the "horary centers" are not uniform, nor are they of equal importance or extension; some of the principal watchmakers have invented methods of their own for special services, which are not of general interest, but the system which radiates from the "horary center" at the Hôtel de Ville (at present the Tuileries) to the twenty *mairies* of Paris is worthy of mention here both on account of its importance and ingenuity. There is a system of telegraph-wires connecting all the *mairies* of the city with the Prefecture of

FIG. 8.—MAP OF PARIS. The two circuits from the Observatory are represented by heavy black lines: the lines from the "horary centers" are represented by dotted lines.

the Seine; the regulator at the Hôtel de Ville automatically sends a current into twenty relays at precisely one hundred seconds before the end of each hour, and thus cuts these wires off from their ordinary telegraphic duty and places them in the circuits of the different *mairies*. Then, at twelve seconds before the end of the hour, the regulator sends another current into the circuit of the *mairies;* this current is stopped precisely at the end of the hour. At each *mairie* the clock automatically shuts off the wire from the telegraph and connects it

with the electro-magnet of the clock at sixty-five seconds before the end of each hour, and reverses the operation at five seconds after the end of the hour. Ten seconds after the end of the hour the first current from the regulator at the Hôtel de Ville automatically stops, and the wires are restored to the telegraph. The clocks at the *mairies*, being thus corrected every hour, run with very small error; but, should for any reason the error become large, or the clock stop, this is indicated automatically by the fact that the current from the "horary center," instead of stopping precisely at twelve o'clock, continues for thirty seconds. By this, the operator at once knows that his clock is wrong, and can have it set right. From the other "horary centers" the number of lines is in no case larger than six, the lines are shorter, and the apparatus accordingly simpler.

But there is another novel and ingenious method for the distribution of time in use in Paris, which, though lacking in accuracy sufficient for scientific purposes, has both convenience and economy to recommend it for general uses, and for that reason has become quite extensively employed in a short time. Abandoning electricity as an uncertain means for moving clock-work at a distance, the inventors of this system, Messrs. Popp and Resch, have accomplished the same object by the use of compressed air and for this reason have called their clocks "pneumatic clocks." They were exhibited at the Exposition at Vienna in 1878, and are now widely distributed in that city.

The essential parts of the system are three: 1. Machinery whose function it is to compress the air, and to propel impulses of the same every minute; 2. Pipes led through the streets and into the houses; 3. Dials provided with mechanism for receiving the pneumatic impulses.

1. At a central point a steam-engine drives pumps which compress air to five atmospheres in a reservoir holding eight cubic metres. This compressed air is sent, by means of a special regulator, into a second receiver called the "distributing reservoir," where the pressure is kept constant at seventh tenths of an atmosphere, or a little less—a pressure determined empirically to be sufficient to move the dials. The "distributing reservoir" is opened to transmit an impulse into the pipes each minute, for about twenty seconds, by a distributing clock (Fig. 4). This consists of two distinct movements. The one to the left, provided with balance-wheel, counter-weights, etc., is simply an ordinary clock, and indicates the hour, minute, and second, as shown in the figure. The movement to the right is contrived especially for moving the distributing valve, R. This valve, ingeniously arranged in such a way that the pressure acts only on a minimum of its surface, is inclosed in a valve-box and has three orifices. The first of these puts the valve in communication with the "distributing reservoir"; the second puts it in communication with the street-pipes; and the third puts the pipes in communication with the atmosphere. The first orifice is always

open ; the other two are normally closed. The automatic escape of the lever G, at the end of each minute, moves the slide-valve, opens the second orifice, and sends an impulse into the pipes ; at the end of a number of seconds, determined by experience and dependent on the length of the pipes (a number which varies from ten to fifteen sec-

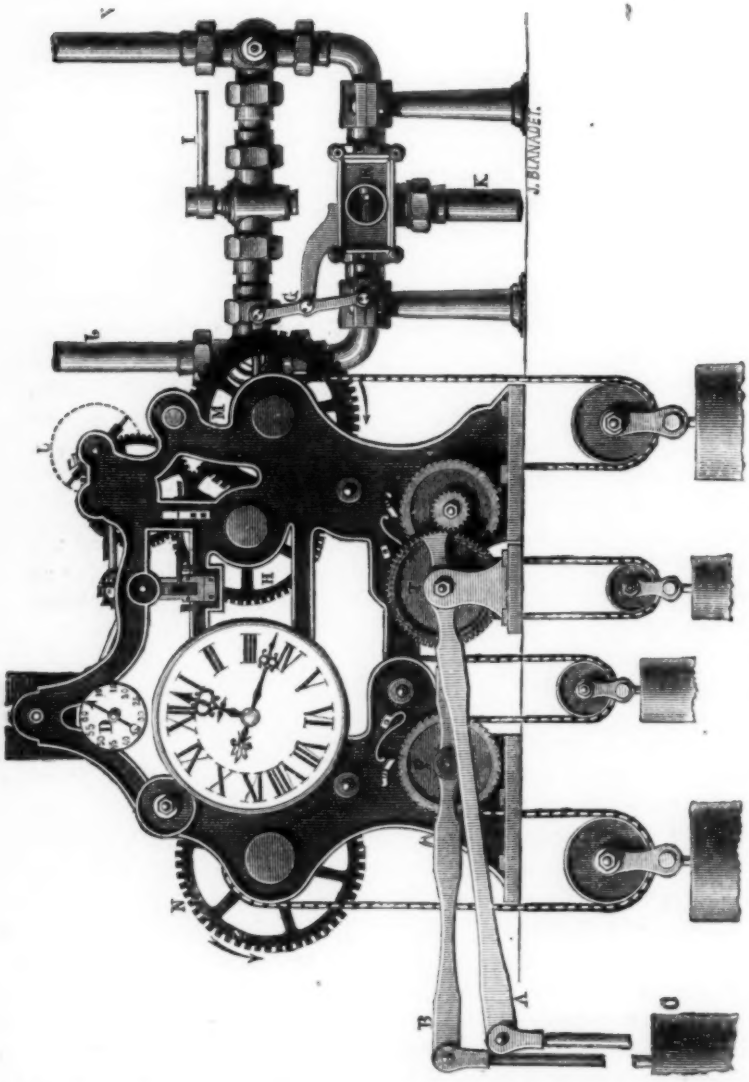


FIG. 4.—DISTRIBUTING CLOCK OF THE PNEUMATIC SYSTEM.

onds), the slide-valve is brought back to its original position by the clock-work, closes the two orifices, and allows the extra pressure which has been introduced to escape into the air. This operation is repeated every minute. The motive-power for the clock-work of both move-

ments is furnished by the compressed air, which automatically lifts the pistons in the cylinders, C, at the end of each minute. The pistons move the levers B and A ; the first of these, B, winds up the counter-weights as much as they have fallen during the preceding minute ; the second, A, imparts motion to the slide-valve.

2. The impulse given by the clock-work is distributed through the city by means of pipes laid like ordinary gas-pipes. In the streets the pipes are of iron, and have a diameter of twenty-seven millimetres (about one inch) ; but in the houses the pipes are of lead, and of different sizes--the diameters being fifteen, six, or three millimetres (practically one half, one quarter, or one eighth of an inch), depending on the number and size of the dials to be operated. These pipes are entirely hidden from view, and in no way interfere with the appearance of the dials.

3. The mechanism of each dial, whatever the size, is shown in essential part in Fig. 5. A leather or rubber flap, seen in the cylinder, receives the impulse as it comes from the pipe and moves a piston, which acts upon a lever-arm arranged by simple connections to move the minute-hand one space forward. The ordinary clock-gearing (not shown in the figure) secures the proper motion for the hour-hand. This part of the apparatus can be inclosed in any case—as plain or as ornamental as desired. The cases are made in all the designs and sizes of ordinary clocks, and appear precisely like them, except that the minute-hands jump suddenly over one space at the end of each minute, and remain stationary during the minute, instead of moving gradually over the space.

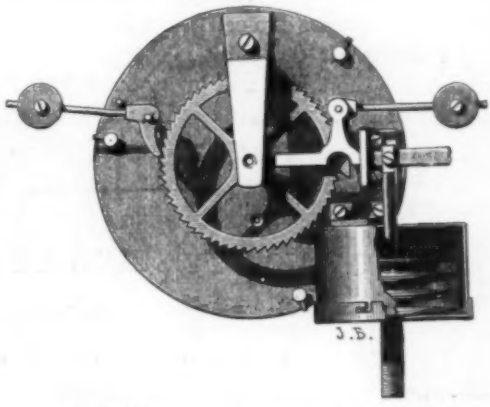


FIG. 5.—MECHANISM OF A PNEUMATIC DIAL.

All the machinery of the system is in duplicate, for use when repairs are needed. Delicate manometers indicate the pressure at all times, and the most approved electric apparatus is used to indicate the particular point at which a defect has occurred. A skilled engineer is on the watch at all times. Provision is also made so that, in case of any interruption in the regulator, the dials may be run by hand. Accuracy of time is secured by daily comparison with the observatory clock.

Excellent as the system is for general uses, the pneumatic dials can not be used for accurate time-work, because it requires in the extreme case, namely, for a distance of twenty thousand metres, at least ten

seconds for the impulse to reach its destination. Thus it will be seen that each dial is slow a certain number of seconds, depending upon its distance from the central station; nor has it been found that the error of any particular dial is constant. But the error will never be allowed to exceed ten seconds. Should the extension of the system require it, Paris will be divided into six districts (surveyed so that no point in the city shall be over twenty thousand metres from a central station), each provided with its central station equipped in other respects as the one described, but all receiving their compressed air from a common reservoir centrally located.

However, there are plenty of people in Paris, as there are, doubtless, in every city, for whom a time even ten seconds in error is accurate enough. The system was put into operation there about March 15, 1880, and in the first four months there were fifteen hundred subscribers, distributed in six hundred houses. The popularity of the pneumatic clocks is due to their convenience and cheapness. The rental is only five centimes (one cent) per day for the first clock; four centimes (eight mills) per day for the second clock; three centimes (six mills) per day for the third and every subsequent clock rented by the same person; and the expense of pipes and apparatus is borne by the company.

JURASSIC BIRDS AND THEIR ALLIES.*

By Professor O. C. MARSH.

ABOUT twenty years ago, two fossil animals of great interest were found in the lithographic slates of Bavaria. One was the skeleton of *Archæopteryx*, now in the British Museum, and the other was the *Compsognathus* preserved in the Royal Museum at Munich. A single feather, to which the name *Archæopteryx* was first applied by Von Meyer, had previously been discovered at the same locality. More recently, another skeleton has been brought to light in the same beds, and is now in the Museum of Berlin. These three specimens of *Archæopteryx* are the only remains of this genus known, while of *Compsognathus* the original skeleton is, up to the present time, the only representative.

When these two animals were first discovered, they were both considered to be reptiles by Wagner, who described *Compsognathus*, and this view has been held by various authors down to the present time. The best authorities, however, now agree with Owen that *Archæopteryx* is a bird, and that *Compsognathus*, as Gegenbaur and Huxley have shown, is a Dinosaurian reptile.

* Read before Section D, British Association for the Advancement of Science, at York, September 2, 1881.

Having been engaged for several years in the investigation of American Mesozoic birds, it became important for me to study the European forms, and I have recently examined with some care the three known specimens of *Archæopteryx*. I have also studied in the Continental museums various fossil reptiles, including *Compsognathus*, which promised to throw light on the early forms of birds.

During my investigation of *Archæopteryx*, I observed several characters of importance not previously determined, and I have thought it might be appropriate to present them here. The more important of these characters are as follows:

1. The presence of true teeth, in position, in the skull.
2. Vertebræ biconcave.
3. A well-ossified, broad sternum.
4. Three digits only in the manus, all with claws.
5. Pelvic bones separate.
6. The distal end of fibula in front of tibia.
7. Metatarsals separate, or imperfectly united.

These characters, taken in connection with the free metacarpals, and long tail, previously described, show clearly that we have in *Archæopteryx* a most remarkable form, which, if a bird, as I believe, is certainly the most reptilian of birds.

If now we examine these various characters in detail, their importance will be apparent.

The teeth actually in position in the skull appear to be in the premaxillary, as they are below or in front of the nasal aperture. The form of the teeth, both crown and root, is very similar to the teeth of *Hesperornis*. The fact that some teeth are scattered about near the jaw would suggest that they were implanted in a groove. No teeth are known from the lower jaw, but they were probably present.

The presacral vertebræ are all, or nearly all, biconcave, resembling those of *Ichthyornis* in general form, but without the large lateral foramina. There appear to be twenty-one presacral vertebræ, and the same, or nearly the same, number of caudals. The sacral vertebræ are fewer in number than in any known bird, those united together not exceeding five, and probably less.

The scapular arch strongly resembles that of modern birds. The articulation of the scapula and coracoid, and the latter with the sternum is characteristic; and the furculum is distinctly avian. The sternum is a single broad plate, well ossified. It probably supported a keel, but this is not exposed in the known specimens.

In the wing itself the main interest centers in the manus and its free metacarpals. In form and position these three bones are just what may be seen in some young birds of to-day. This is an important point, as it has been claimed that the hand of *Archæopteryx* is not at all avian, but reptilian. The bones of the reptile are indeed there, but they have already received the stamp of the bird.

One of the most interesting points determined during my investigation of *Archæopteryx* was the separate condition of the pelvic bones. In all other known adult birds, recent and extinct, the three pelvic elements, ilium, ischium, and pubis, are firmly anchylosed. In young birds these bones are separate, and in all known Dinosaurian reptiles they are also distinct. This point may, perhaps, be made clearer by referring to the two diagrams before you, which I owe to the kindness of my friend Dr. Woodward, of the British Museum, who also gave me excellent facilities for examining the *Archæopteryx* under his care. In the first diagram, we have represented the pelvis of an American Jurassic Dinosaur allied to *Iguanodon*, and here the pelvic bones are distinct. The second diagram is an enlarged view of the pelvis of the *Archæopteryx* in the British Museum, and here too the ilium is seen separate from the ischium and pubis.

In birds the fibula is usually incomplete below, but it may be coossified with the side of the tibia. In the typical Dinosaurs, *Iguanodon*, for example, the fibula at its distal end stands in front of the tibia, and this is exactly its position in *Archæopteryx*, an interesting point not before seen in birds.

The metatarsal bones of *Archæopteryx* show, on the outer face at least, deep grooves between the three elements, which imply that the latter are distinct, or unite late together. The free metacarpal and separate pelvic bones would also suggest distinct metatarsals, although they naturally would be placed closely together, so as to appear connate.

Among other points of interest in *Archæopteryx* may be mentioned the brain-cast, which shows that the brain, although comparatively small, was like that of a bird, and not that of a Dinosaurian reptile. It resembles in form the brain-cast of *Laopteryx*, an American Jurassic bird, which I have recently described. The brain of both these birds appears to have been of a somewhat higher grade than that of *Hesperornis*, but this may have been due to the fact that the latter was an aquatic form, while the Jurassic species were land birds.

As the *Dinosauria* are now generally considered the nearest allies to birds, it was interesting to find, in those investigated, many points of resemblance to the latter class. *Compsognathus*, for example, shows in its extremities a striking similarity to *Archæopteryx*. The three clawed digits of the manus correspond closely with those of that genus; although the bones are of different proportions. The hind-feet also have essentially the same structure in both. The vertebræ, however, and the pelvic bones of *Compsognathus* differ materially from those of *Archæopteryx*, and the two forms are in reality widely separated. While examining the *Compsognathus* skeleton, I detected in the abdominal cavity the remains of a small reptile which had not been previously observed. The size and position of this in-

closed skeleton would imply that it was a fœtus; but it may possibly have been the young of the same species, or an allied form, that had been swallowed. No similar instance is known among the Dinosaurs.

A point of resemblance of some importance between birds and Dinosaurs is the clavicle. All birds have those bones, but they have been considered wanting in Dinosaurs. Two specimens of *Iguanodon*, in the British Museum, however, show that these elements of the pectoral arch were present in that genus, and in a diagram before you one of these bones is represented. Some other *Dinosauria* possess clavicles, but in several families of this sub-class, as I regard it, they appear to be wanting.

The nearest approach to birds now known would seem to be in the very small Dinosaurs from the American Jurassic. In some of these, the separate bones of the skeleton can not be distinguished with certainty from those of Jurassic birds, if the skull is wanting, and even in this part the resemblance is striking. Some of these diminutive Dinosaurs were perhaps arboreal in habit, and the difference between them and the birds that lived with them may have been at first mainly one of feathers, as I have shown in my memoir on the *Odontornithes*, published during the past year.

It is an interesting fact that all the Jurassic birds known, both from Europe and America, are land-birds, while all from the Cretaceous are aquatic forms. The four oldest known birds, moreover, differ more widely from each other than do any two recent birds. These facts show that we may hope for most important discoveries in the future, especially from the Triassic, which has as yet furnished no authentic trace of birds. For the primitive forms of this class we must evidently look to the Palæozoic.

WHAT IS TRANSCENDENTAL PHYSICS?

By PAUL R. SHIPMAN.

THE theory of a fourth dimension of space has lately been brought forward somewhat prominently, under the imposing title of "Transcendental Physics," by Mr. John Charles Frederick Zöllner, Professor of Physical Astronomy in the University of Leipsic, although the learned professor, it should be said, imputes the suggestion of the theory primarily to Kant, and secondarily to Gauss, the celebrated mathematician of Göttingen, both of whom, he says, struck out the thought. In this, it is possible, the professor does himself less than justice.

Gauss had large expectations from the geometry of position, but its development, as contemplated by him, does not appear to have

included the development of a fourth dimension, and we know he expressed a lofty scorn for table-tippings and other things of the sort, to which the new dimension, it would seem, has thus far lent itself exclusively. Kant, it is true, admitted the possibility of other dimensions, but derived it from the impossibility of knowing what exists outside of the limits of our faculties, and consequently of legitimately affirming or denying anything about it. He suggested the possibility of other dimensions of space, and, for that matter, the possibility of no space, but not the possibility of the discovery and comprehension of either by the human mind. So far from this, he distinctly suggested the reverse, actually citing, as an example of truths "always united with the consciousness of necessity," the proposition, "Space has only three dimensions"; and, since a necessary truth is one of which the contrary is inconceivable, he could not have suggested, without self-contradiction, that space may have more than three dimensions. If other dimensions exist, they exist, according to Kant, not for man, but for other orders of beings, endowed with corresponding forms of perception—exist as parts of the original furniture of the intelligences of other spheres—hypothetical properties of hypothetical creatures in hypothetical worlds, one and all of which transcend our faculties. This, however, is by no means the theory of Professor Zöllner.

"In my first treatise, 'On Action at a Distance,'" says that distinguished physicist, "I have discussed in detail the truth, first discovered by Kant, later by Gauss and the representatives of the anti-Euclidian geometry, viz., that our present conception of space, familiar to us by habit, has been derived from experience, i. e., from empirical facts, by means of the causal principle existing *a priori* in our intellect. This in particular is to be said of the three dimensions of our present conception of space. If from our childhood phenomena had been of daily occurrence, requiring a space of four dimensions for an explanation which should be free from contradiction, i. e., conformable to reason, we should be able to form a conception of space of four or more dimensions. It follows that the *real* existence of a four-dimensional space can only be decided by *experience*, i. e., by observation of *facts*. A great step has been made by acknowledging that the possibility of a four-dimensional development of space can be understood by our intellect, although, on account of reasons previously given, no corresponding image of it can be conceived by the mind." Probably the first thought which will occur to the intelligent reader of this passage is that Professor Zöllner mistakes Kant; and perhaps the second thought will be that the professor mistakes himself. If these impressions prove just, he may find one day that his theory of a fourth dimension has suddenly passed away more completely, if less mysteriously, than the book from the slate at Vienna, or the round-table from the sitting-room at Leipsic. Let us inquire whether or not they are just.

Professor Zöllner thinks "our present conception of space" has been

derived from experience, "by means of the causal principle existing *a priori* in our intellect." Kant held, on the contrary, that our idea of space is not a mere conception, but a pure intuition; that it belongs to the faculty of sense; that it is in fact one of the necessary conditions of sensation, without which experience itself is impossible; and, finally, that the "causal principle" originates in the higher faculty of the understanding, to which sense delivers up its presentations ready cast in the mold of space. In the philosophy of Kant, therefore, the "causal principle" has nothing to do with the origin of the idea of space, which emerges before sensation rises to the sphere of that principle. Kant, among his endless subtilties, distinguished indeed between the form of the intuition and the formal intuition, in which space is represented as an object, and with which unity of representation is given through the understanding; but the determination of this unity, he taught, is contained *a priori* in the intuition, not developed *a posteriori*, gradually or otherwise. As a formal intuition, space, like every other sensuous intuition, Kant maintained, is subject to the categories of the understanding, causality included, but the subjection, besides extending to all sensuous intuitions alike, is *a priori*, and as such incapable of expansion or contraction by experience, the possibility of which presupposes it. In the Kantian theory causality has nothing special to do in any mode with the idea of space in any aspect. In common with the other categories, it is simply presupposed in every intuition of sense, that of space with the rest. It lies at the bottom of the possibility of experience in general. Moreover, an *a priori* principle, as already intimated, is not a germ susceptible of growth, but rather a die, which for ever impresses the same form. A new kind of impression necessitates a new kind of die, and, if you would have a new kind of determination, you must get a new *a priori* principle; a given principle can not be altered to suit emergencies. Experience may sharpen but not remodel it: as well expect the metal to remodel the die that cuts it. An *a priori* principle reconstructed *a posteriori* is an article which the author of the "Critique of Pure Reason" happened never to turn out from his workshop, although, if it had found entrance, he infallibly would have turned it out in double-quick time.

Yet Professor Zöllner thinks not only that the "causal principle" is a special agent in producing our conception of space, but that "this, in particular, is to be said of the three dimensions of our present conception of space," implying thereby, in the teeth of the Kantian dogma, that we have arrived by degrees at a conception of three dimensions, halting for a time at two, if not halting before at one. Indeed, Professor Crookes, expounding in "The Quarterly Journal of Science" Professor Zöllner's theory, affirms as much explicitly. "The totality of all empirical experience," he states, doubtless repeating the language of his theorist, "is communicated to the intellect by the senses, i. e.,

by organs which communicate to the mind all the sensuous impressions which are received at the *surface* of our bodies. These impressions are a reality to us, and their sphere is two-dimensional, acting not in our body, but only on its *surface*. We have only attained the conception of a world of objects with three dimensions by an intellectual process. What circumstances, we may ask, have compelled our intellect to come to this result? If a child contemplate its hand, it is conscious of its existence in a double manner—in the first place, by its tangibility; in the second, by its image on the retina of the eye. By repeated groping about and touching, the child knows by experience that his hand retains the same form and extension through all the variations of distance and positions under which it is observed, notwithstanding that the form and extension of the image on the retina constantly change with the different position and distance of the hand in respect to the eye. The problem is thus set to the child's understanding: How to reconcile to its comprehension the apparently contradictory facts of the *invariableness* of the object, together with the *variableness* of its appearance. This is only possible within space of three dimensions, in which, owing to perspective distortions and changes, these variations of projection can be reconciled with the constancy of the form of a body." The italics in this extract, as in the preceding one, are the author's.

Professor Zöllner describes the problem which he conceives to be set before a child. The problem which the professor seems to have set before himself may be described thus: Given a tatter of Kantism, a scrap from the received doctrine of our acquired perceptions, and the rickety figment of a fourth dimension, to evolve a theory which shall save the fourth dimension at all hazards. And we have here the outcome. His theory is, that our idea of space is not, what Kant declared it to be, a pure intuition, constituting one of the necessary conditions of experience, but a conception gradually arising from experience, modified by the "causal principle," or, more precisely, modifying the "causal principle," which last the professor apparently regards as a kind of store-house of potential dimensions, projecting into space a new dimension whenever hard pressed by the contradictions of things, very much, one may suppose, as M. Faure's secondary battery gives out its store of energy at the touch of the operator. In short, Professor Zöllner holds that our idea of space is not intuitive, but ratiocinative, limited only by the diversity of contradictions that present themselves to thought, each of which, if otherwise irreconcilable, is pregnant with a new dimension. A child, for instance, because sensuous impressions are received at the surface of its body (and partly, we may presume, because it takes logical contradictions easy, and is not particularly strong in ratiocination anyway), perceives only two dimensions, we are told, until such time, indeed, as, grown impatient of contradictions, and withal a mighty cause-hunter, it seeks to recon-

cile the invariableness of an object with the variableness of its appearance at different distances, when, *presto*, forth from the battery of the "causal principle" streams a third dimension, to smooth away the contradiction, and solve the problem; although how, meanwhile, the two-dimensional little one contrives to crawl over the house-dog, or to keep its own body in its own sight when lifted out of the cradle, or to "contemplate its hand," and go through with "repeated groping about and touching," without stumbling on the third dimension, is a puzzle that must tax the resources even of transcendental physics. To them I leave it.

Professor Zöllner's theory, it goes without saying, is important, if true; for, if one contradiction may determine a new dimension of space, another contradiction, by the same token, may determine another new property, and so on, till everything shall be made plain, and we "be as gods." The theory, as will be observed, is propounded in its seminal form; but its capabilities of explanation are restricted only by the number of possible contradictions inexplicable without it, so that, if capable of solving a single problem insoluble in any other way, it is capable of solving every insoluble problem—is a philosophical menstruum, a logical catholicon, a key to all the mysteries that mind is heir to. It is this, or nothing; but this, alas! is quackery. Yet Professor Zöllner is no quack. He is a trained scientist, enthusiastic without doubt, but equally without doubt sincere. What, then, is at fault? To be sure, he is a man with a theory, and that means a good deal; but it does not cover the whole ground. He, above all, is a man with an impossible fact. By this he has fallen. Theorizing to *explain* a fact is hazardous enough, and theorizing to *prove* a fact more hazardous still, but the man who theorizes to *prove a fact beyond the bounds of human knowledge* is lost; and this is the predicament of our worthy professor. Through his zealous efforts to prove a fourth dimension he has got psychology at sixes and sevens. In framing his theory of space, he unconsciously has made hash of Kant's theory, as in expounding it he has unconsciously perverted Berkeley's theory of vision; his theory, accordingly, is itself a hash. In other words, Professor Zöllner, having mutilated Kant, and hacked the fragments, has mixed up with the remains a sprinkling of Berkeley (after vitiating it), and taken the resulting hodge-podge as his theory of space, which, like the honey in Samson's riddle, comes out of the carcass of the lion he has rent, though in his case, unhappily, the bees have swarmed from his own bonnet. It would be superfluous to characterize seriously his account of the origin of our idea of space. It is enough to say that the account has no warrant in the teachings of Kant, or of any other metaphysician, from Zeno to Spencer. It is not Kantian in the least, but purely Zöllnerian; and, as John Wilkes acknowledged that he was never much of a Wilkesite, so Professor Zöllner, if he some day becomes as well versed in psychology as he is in physics, will be tempted

to deny that he was ever a Zöllnerite at all; and, should he yield to the temptation, the recording angel might fitly blot with a tear the record of the lapse. At all events, Professor Zöllner does not understand Kant.

Does he understand himself? "If from our childhood," he says, "phenomena had been of daily occurrence, requiring a space of four dimensions for an explanation which should be free from contradictions, i. e., conformable to reason, we should be able to form a conception of space of four or more dimensions. It follows that the *real* existence of a four-dimensional space can only be decided by *experience*, i. e., by observation of facts." Yes, it all depends on experience, which, as every good Kantist will tell you, furnishes the matter of our cognitions, while the mind furnishes the form, the two elements uniting in the act of cognition; insomuch that the form without the matter is void, as the matter without the form is undetermined. Wherefore, we can have no conception the matter of which has not been furnished by experience, or, as a strict Kantist would say, by sensibility. But what experience, known or conceivable, can furnish the matter of the conception of a fourth dimension? Contradictions, which nothing but a fourth dimension will reconcile, answers Professor Zöllner—such as the tying of knots in endless cords, disappearance and reappearance of solid objects, passage of a shell through a table, impressions of feet on the inner sides of a closed book-slate, and other "contradictions" emerging or appearing to emerge in the presence of Dr. Slade. But contradictions are objects not of the sensitive faculty but of the understanding, and, however amazing, do not furnish new matter of conception; they merely call for new applications or new combinations of the conceptions we have. A knot tied in an endless cord is, so far as presented to us, a phenomenon within three dimensions, and, though we may not know how the knot was tied, our ignorance of the way of tying it can give us no new matter of thought. It is an appeal to our sense, not to our senses; and the office of our sense is to receive and organize the matter of thought, not give it. The mind has no portal through which a fourth dimension can enter, no chamber in which it may lodge. To assume that, because the contradictions in question are irreconcilable, they *ipso facto* present to our mind a new dimension of space, in the perception of which only they become reconcilable, is to make the simple inexplicability of a problem not only the verification of a given solution of it, but the occasion of a new experience in sense, and a new form in thought—a change, that is, in the constitution of our faculties. If a theory explains a phenomenon, the theory is so far confirmed; but, if the phenomenon is comprehensible only by a theory which is incomprehensible, the phenomenon itself is incomprehensible, and, a sensible person would say, there is an end of it. With Professor Zöllner, however, there is only the beginning of it, the incomprehensibility of the phenomenon,

he contends, verifying the incomprehensible theory, which in return explains the phenomenon "conformably to reason." This is arguing in a circle as vicious as ever a bedlamite whirled in. From the point of view of any system of philosophy under heaven, it is vile metaphysics, and viler physics!

Could Kant have been a Zöllnerist, instead of a Kantist, we should never have heard of his wrestle with the famous antinomies, which in that event would have disappeared before a new world and a new mind, evoked by the contradictions themselves, from which he would have freed his reason by the cheap and easy method of a new dimension of space, and, if necessary, a new dimension of time, with as many more transcendent discharges from the "causal principle" as the pinch required; but the philosopher of Königsberg knew not this master-key of mysteries, and, had it been put before him, we can faintly imagine with what pulverizing force he would have brought down on it his Thor-hammer, unless, forsooth, it vanished before the "whiff and wind" of the ponderous weapon. Germany is responsible for some wild philosophers, but Professor Zöllner, it must be confessed, has "bettered the instruction" of the wildest of them. What Kant styled "the error of inactive reason," Zöllner runs into "the very error of the moon." Assuredly he leads the canons of scientific inquiry a pretty dance. It is not reckoned sound philosophy to multiply causes unnecessarily, or to assume unknown causes before exhausting known ones; but what should be thought of a method which, not content with brushing aside the law of parcimony, goes on to account for an effect by assuming a cause beyond the grasp of the intellect—to explain what is not understood by what can not be conceived—to make known the unknown by the unknowable; and which, not stopping at this, turns round, and from the mystery of the effect infers not merely the reality of the inconceivable cause, but the evolution of a new faculty to match it? If ever there was pressing need for the application of Occam's razor, it surely is afforded by the theory of this German scientist, whose general method in his professional domain, we may be sure, it does not fairly exemplify. If it did, his occupancy of a chair in the University of Leipsic would be almost as great a marvel as the fourth dimension itself.

"A great step has been made," Professor Zöllner congratulates himself, "by acknowledging that the *possibility* of a four-dimensional development of space can be understood by our intellect." This possibility our professor, of course, fancies that he himself understands; and no doubt he is as capable of understanding it as anybody else is. But does he understand it? Nay, can he think of it? To think of the possibility of a thing is to put together in thought the terms of the proposition asserting the possibility. In the case under notice, can Professor Zöllner do this? He owns that he can not. "No corresponding image of it can be conceived by the mind," he avows. If

he can not imagine the thing, he can not imagine the possibility of the thing, the imagination of which involves the imagination of the thing itself; possibility, as every Kantist should know, being simply a mode of conceiving the thing. And what he can not imagine he will scarcely insist that he understands. As a rule, we do not understand what we can not conceive. They may order things differently in Germany; but, as yet, Professor Zöllner is the only evidence of it that we have, and it is now tolerably clear that he does not think what he thinks he thinks. He deceives himself. He will not venture to say, for example, that he understands the possibility of a round triangle, or of a whole equal to its part, or of three and two making seven. Yet it is certain that he understands any one of these propositions as truly as he understands the possibility of a fourth dimension: which is as good as saying that the latter proposition is without meaning to him, as to every other human being, and can have no meaning to any mortal so long as the constitution of our minds remains what it is. Professor Zöllner, able and accomplished though he be, is the dupe of words. It is not possible to understand the possibility of a fourth dimension. *Fourth* we know, and *dimension* we know; but what is *fourth dimension?* The realities denoted by the words can not be united in thought. The phrase is perfectly empty—a sign that signifies nothing. To use a Wall-Street figure, it is a metaphysical kite, not worth the breath that flies it.

Professor Zöllner's diagrams—intended to show how a twist in a cord, which we three-dimensional beings can do or undo by turning over a part of the cord, could not be done or undone by two-dimensional beings without making one end describe a circle, and, by means of this showing, to illustrate the possibility of a four-dimensional creature tying and untying knots in an endless cord as easily as we do and undo twists in it—are sheer delusions. A cord, whether laid on itself or extended in only one direction, and though conceived of the utmost conceivable thinness, can not be conceived with less than three dimensions. Nor can a line or a point. When we think of a mathematical plane or line or point, we do nothing more than fix our attention on length and breadth, regardless of thickness; or on length, regardless of both breadth and thickness; or on position, regardless of all three: we think away from what remains, but we do not think it away. It is thrust off, but not out—minimized, not annihilated. No effort of thought can annihilate it. Professor Zöllner either mistakes the hyperboles of geometry for literal expressions, or supposes that they are as valid for what he calls transcendental physics as for physics, forgetting that in the former, if we vex them at all, we must pass behind symbols to the things symbolized, which, if inconceivable, are of no use in aiding us to conceive anything else. And that is the trouble with his diagrams. They symbolize inconceivable things, whereas, to answer his purpose, they should symbolize conceivable ones; seeing that the ordinary

acceptation of lineal diagrams, although sufficiently true for the conclusions of mathematics, does not cut deep enough for a fourth dimension, which, if diagrams are to facilitate our comprehension of it, needs the exact truth of what they postulate. Less than this will leave us where it finds us—"cabined, cribbed, confined" in three dimensions. Professor Zöllner will pardon a little rigor in the interpretation of figures employed to throw light on a theory so occult. For the purpose he has in hand, which lies considerably deeper than the lowest foundation of mathematical reasoning, we are bound to demand that his diagrams shall represent in reality exactly what they purport to represent; that, in plain words, they shall stand for real surfaces without thickness, and real lines without breadth or thickness. But these things do not exist for the human mind. They are incapable of representation in thought. If they were conceivable, they might then assist us to comprehend a fourth dimension, because, if we once cross the absolute limits of conceivability, there is no telling what we might or might not comprehend: presumably new heavens and a new earth would open on us, and certainly a new mind would open in us. But they are not conceivable, and the speculation is idle. For this reason, if no other, Professor Zöllner's digrammatic illustrations do not illustrate. They but offer one inconceivable thing to help us conceive another. They begin and end in nothing.

It turns out as was foreseen. Professor Zöllner understands himself even less than he understands Kant. It is very sad; yet the sadness has a silver lining. His merit is greater than he has dreamed. Although evidently a modest man, his modesty can not be spared. He is himself the author of his theory. He owes nothing to Kant. Let justice be done, though the blushes rise. But justice requires another word. Professor Zöllner can not imagine the possibility of the truth of his theory. He can not represent to his own mind the theory itself. It is unthinkable. Not to put too fine a point on it, his theory, in philosophical strictness, is pure nonsense. Let justice be done, though the blushes spread. We are now in a position to answer the question at the head of this paper, and the answer can hardly be put more aptly than in the terms of a definition of metaphysics familiar to every civilized country, and claimed as its own, I believe, by each in turn, if not simultaneously: When Zöllner tells the world what the world can't understand, and what Zöllner doesn't understand himself, that is transcendental physics.

NEW GUINEA AND ITS PEOPLE.*

By Rev. W. G. LAWES.

THAT part of the coast-region of New Guinea extending from Yule Island to its eastern extremity presents a striking contrast to the central part of the island, or that lying to the west of the Gulf of Papua. There all is lowland, not visible at sea a few miles distant. Here, farther east, we have a lofty mountain-range running all along the southeastern peninsula, and reaching in Mount Owen-Stanley the height of thirteen thousand feet. Variety and beauty are given to the landscape by hills of every imaginable shape, which appear gray and barren, or green and fertile, according to the season. Only a few of the rivers in this part of New Guinea are of considerable size, but some fine harbors have been found, and the voyages of the mission-steamer Ellengowan have resulted in the marking of many reefs, bays, creeks, headlands, and islands on the chart, to the increased safety of navigation. The flora and fauna are to a great extent Australian. Coarse kangaroo-grass covers much of the land, and the open forest country is studded with white-gum, wattle, and other Australian trees. It is only near the water-courses and rivers, or in the gorges and ravines of the hills, that the vegetation is luxuriantly tropical. Here are the areca-palm, the bread-fruit, wild mango, and chestnut, the pandanus in several varieties, crotons of variegated leaf, crimson *Dracænæ*, orchids and creepers in great variety, and ferns in abundance. Near the coast, and especially about Hood Bay, groves of cocoa-nut trees, miles in extent, cast their grateful shade. Some districts are hungry and barren, while in others food is plentiful, yet in all the bill of fare lacks variety. Every traveler makes the acquaintance of the palm called the "lawyer." It has received its name, I suppose, from the fact that at the back of its fronds are double rows of hooked thorns. These lay hold of any unwary passer-by, and the more he struggles to escape the tighter he is held. It is only by going back and patiently unhooking, that escape from its grasp is possible.

The fauna is also to a great extent Australian. Flocks of small kangaroos, or wallabies, rush away from one's path in journeying inland. The opossum, *cuscus*, flying phalanger, and bandicoot, are other representatives of the marsupials. I have had the honor of discovering an *echidna*, or prickly ant-eater; also an animal of the marsupial order, closely allied to the North Australian species.

* Abstract of an address before the Royal Geographical Society of London. The statements here given are the result of observations made by the author during three years' residence, from 1874 to 1877, as a missionary of the London Missionary Society, on the southeast coast of New Guinea. During the period named, he made several journeys into the interior, and more than one voyage along the coast to the east.

There are no large quadrupeds in this part of New Guinea. The largest known at present is the pig. This is found wild in the bush, and is also domesticated. Fat pork is to the natives of New Guinea a dish deemed worthy of the gods, but not often conceded to mortals. We introduced a new species of hog, which is greatly prized.

Many of the birds are of Australian species—such as the "magpie," "laughing jackass," and "leatherhead," of the Australian colonists, which are very common everywhere along the coast, and parrots, paroquets, and cockatoos are very numerous. There are other birds, however, peculiar to the island. New Guinea is particularly rich in birds-of-paradise, of which beautiful and characteristic group no fewer than twenty different species have been found. Only two are, however, known in the Port Moresby district. One of these, the *Paradisea Raggiana*, is comparatively new, and peculiar to the south coast; while the other, the king bird-of-paradise, has been long known to naturalists. They are very shy, difficult to see, and more so to shoot. I have had the honor of making and eating bird-of-paradise soup. It is very unparadisaical in its flavor. The cry of the bird-of-paradise is something between the quacking of a duck and the cawing of a crow. The mound-building fowl and the bush-turkey are common, and so on the river-banks is the magnificent crowned pigeon, the *Goura coronata*. This is not to be despised by the sportsman. The bird is as large as a small turkey, and the flesh white and delicate in flavor. The bower-bird is peculiar, making a bower to play in and adorning it every morning. Other birds are the hornbills, which make a great noise while flying, and the cassowaries, which are the fleetest and strongest animals the natives are acquainted with.

The climate has hitherto been very trying, both to Europeans and Polynesians. The average maximum temperature for the year at Port Moresby was 86.71°. Foreigners suffer from malarial fevers, but the natives are healthy, though suffering slightly from fever, and wonderfully free from European diseases, except the small-pox.

Although Mr. Wallace has spoken of the natives as one race, those who have seen the inhabitants in the southeast find greater difficulty in classifying them. All agree in testifying to the great variety of physiognomy and the apparent difference in shape of skull in almost every district. Whatever the true typical Papuan may be, I have seen natives who possess many of the characteristics said to be distinctive, with others quite at variance with them. In a letter I recently received from Professor Giglioli of Florence, he speaks of having seen the large collection of skulls made by Signor D'Albertis in his voyage up the Fly River, and says: "The great variety in the shape of the crania of some of the inland natives has sorely puzzled me. Indeed, the only feasible explanation is, that there has been a great mingling of races in that great island."

The difference in color is very marked. To the west, black natives

are found, while from Redscar Bay eastward a light-brown race inhabits the coast. On the mountains, in the interior, are people intermediate between these two in color, and essentially different in all their habits. I should say these are the true aborigines of this part of New Guinea, while the coast tribes, black and brown, are probably settlers. The light-haired natives belong undoubtedly to the same

FIG. 1.—DURABI, A NATIVE OF KIWAI ISLAND, AT THE MOUTH OF THE FLY RIVER. (From "New Guinea, what I Did and what I Saw." By L. M. D'Albertis.)

race as the New-Zealanders, Tahitians, Samoans, etc., but are so split up and divided that every few miles of coast brings you to a people speaking a different language from those you have just left. These are often dialects, but are quite as dissimilar as those spoken in the various islands of Eastern Polynesia. Altogether, I know of twenty-five different languages spoken in the three hundred miles of coast I am personally acquainted with. My previous acquaintance with several languages of Eastern Polynesia was a great help in acquiring that of the people among whom I was living in New Guinea. I had the pleasure of reducing two of these to a written form, and getting books printed in them, and before I left New Guinea I had the greater pleasure of hearing some of the native children read fluently in their own language.

The men are of a warm brown color, muscular and well developed, straight and agile, with fairly well-formed noses, and lips neither protruding nor thick. Many have intelligent faces, and all glory in their huge mop of hair. They carefully pull out every hair from their

beards, and at times shave off their eyebrows and the hair from their temples; and most wear ornaments in their noses and tightly plaited armlets, which they make to serve them as pockets. The women wear a decent girdle or petticoat, reaching from the hips to the knees, are tattooed very closely, pierce their ears with many holes, load them down with ornaments, and shave their heads when they are married. All their muscles and limbs have free action, they are stately and graceful in all their movements, and their use of colored leaves and flowers no rules of art could improve. The position of the women is not so low and degraded as it often is among barbarous races.

The houses are built on piles, and we are everywhere reminded of the prehistoric lake villages of Europe. Port Moresby consists of two villages standing on the beach just below high-water mark. The houses are not built on a platform, as they are often represented, but the piles also form the posts of the houses. The natives live, as we should say, in the roof. The huts are made of thatch and wood, and floored with the sides of old canoes, which are adzed down to some approach to flatness. In the interior the floor is made of the mid-rib of the sago-palm fronds. It is light and springy, but not good to sleep on, as I can testify from experience. There is always a square fire-place, made with earth, in the center of the house. You are a fortunate visitor if you go when the fire is out, and thus escape being blinded by the smoke. All along the coast the houses are built in the same way, with slight variations in the shape of the roofs. Some look like a whale-boat, depressed in the center, while others resemble the keel of a boat turned upside down. In many cases the village stands a good way out to sea, and is surrounded by water even at low tide. We could steam down the street of many of them in our little mission-steamer, and in several cases we used to anchor alongside the houses. The boys and girls can sit in the door-way and fish. The houses are detached, but are generally connected by a pole laid from one veranda to another. The shoeless feet of the people enable them to run along these, and they laugh at our objection to so round and slippery a bridge.

The canoes of the Papuans furnish an interesting illustration of the earliest styles of naval architecture. As the people are largely dependent on the sea for means of subsistence and transport, every village has its fleet of canoes, of all sizes. Those at Port Moresby consist simply of a hollowed log, pointed at each end, and attached to an outrigger. All are propelled by paddles, or by mat-sails whenever there is any wind. When longer voyages are undertaken, four or five, and even ten, canoes are lashed together. These are decked over with poles, houses are built at each end, covered with thatch, and a sort of bulwarks made of the same material all round the sides. A mast is raised, consisting of the stem of a small tree with its principal roots, which latter are lashed to the deck, and then a huge mat-sail, crab-claw

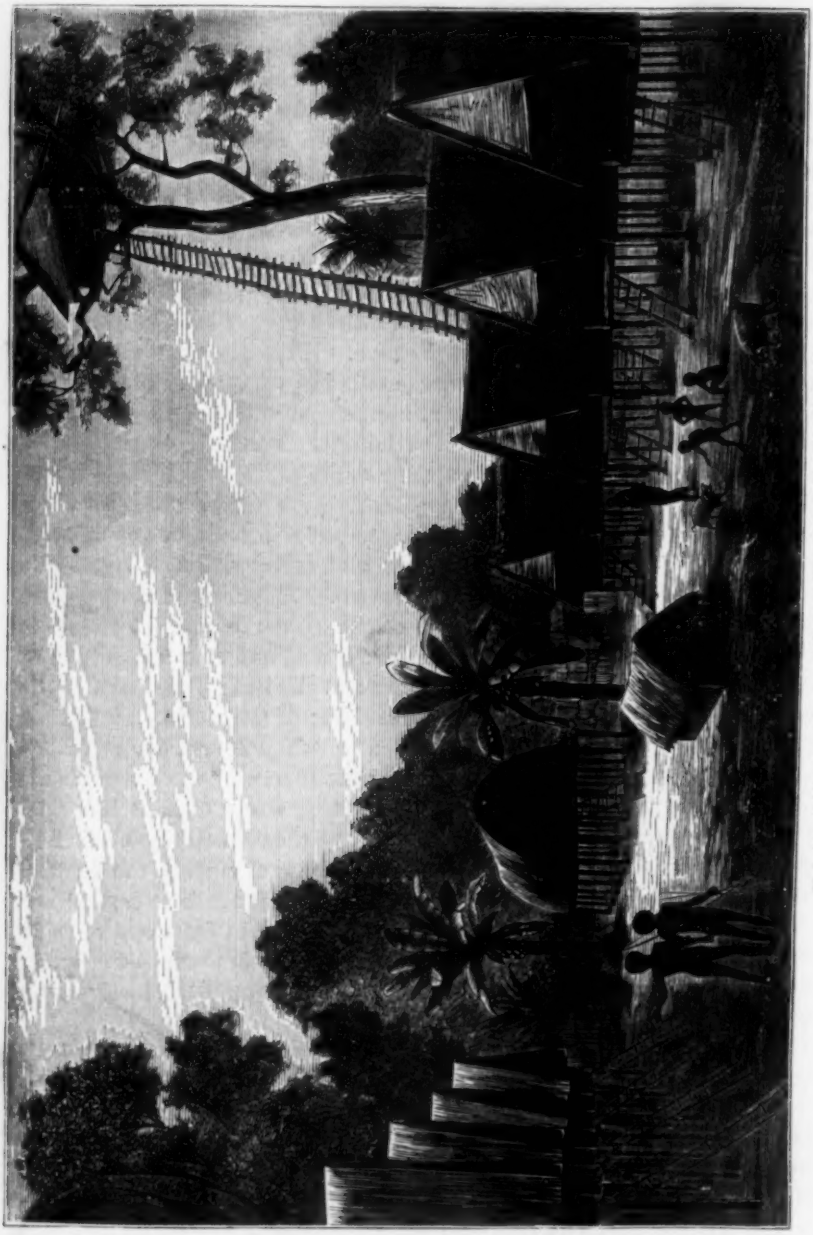


FIG. 2.—A VILLAGE OF THE MAIORI-PAPUANS. (L. M. D'Albertis.)

shape, is hoisted by a rope passed over a fork at the top of the mast. A more unwieldy, unseaworthy-looking craft it is impossible to conceive, and yet they make long voyages in such a vessel—to places two hundred miles distant. They have been aptly described as huge floating hay-stacks. As they can only run before the wind, the crew choose

the end of one monsoon to go to their destination, waiting the setting in of the other to return. Farther to the east the style of the canoes improves. At Orangerie Bay they are adorned with elegant and elaborate carvings, and are often very well shaped, with seats for as many as eighteen paddlers. Sometimes two or three are lashed together, while the captain sits on a raised deck between them. The war-canoes of this kind are elaborately ornamented with carved figure-heads, painted black and white, and decorated with many streamers. The women can paddle their canoes quite as well as the men; and I have seen a double canoe, propelled by twenty-four women, flying over the water, the women keeping perfect time with their paddles.

The people are still in the stone age, for iron and its uses are unknown among them. They are all gardeners, and cultivate the soil carefully, with a set of agricultural implements consisting of two pointed sticks, which serve them for plow and harrow, spade and rake. One stick is inserted five or six inches into the soil, and then the other at an angle with it; with the leverage thus obtained a sod is turned, and, this being done in regular order, a field looks, when finished, almost as if it had been plowed. Bananas are planted in these furrowed gardens. In other cases the large sods are broken up, the weeds picked out, and the whole smoothed over by the stick, until it has the appearance of a well-raked, carefully cultivated English garden. The men do the heavier work of digging, while the women plant and weed. All their gardens are inclosed by well-made fences.

Hunting the wild-pig and kangaroo are favorite sports. With no other weapon than a smooth-pointed spear and a coarse net, they obtain enormous quantities of kangaroo-meat. All the men and boys join in the grand hunts. A tract of land is selected on a day when the trade-wind is blowing steady and strong. The hunters pull up the dry grass in a narrow belt to leeward, and place their nets along the strip, each man's net being joined to his neighbor's, so that a continuous fence of nets is formed across one side of the hunting-ground. The men stand behind this barrier, with their spears and dogs, and the grass is set fire to all along the line to windward. The animals are driven, by the fire and smoke and boys, up to the nets, where their chances for escape are very small. The fishing is all done with nets.

The people have no metallic vessels, or ovens of any kind. Most of the food is boiled, and, before it can be cooked, the women have to make the pot to boil it in. They make very good pottery, which is slightly burned after being dried in the sun. They use no wheel, and yet they make well-shaped globular vessels. Roasting over a slow fire is also often practiced, and the South-Sea Island mode of cooking with hot stones is employed by the inland tribes. All the food is well cooked; and they look upon us as barbarous for eating our meat, as they say, half raw. This does away altogether with the idea of gnawing and tearing which we generally associate with eating without

knives and forks. The water in which food has been boiled is generally drunk, even when it is fish-broth. This is their only warm drink. Tea and coffee are unknown. They have no intoxicant, and are content and healthy with no stronger beverage than the fresh cocoa-nut and running stream afford.

The women excel in making netted bags of all sizes. The large bags, which are used by the women to carry their burdens in, and also as cradles, were interesting as the only article I had met which was also made by the aborigines of Australia. The women are charged with the bartering, and are skillful at driving a bargain; and they have the Eastern custom of going for water at daybreak, carrying the water on the head or shoulder, and meeting for gossip at the well.

FIG. 3.—FAUDORE, A DOREY PAPUAN. (L. M. D'Albertis.)

When food is plentiful, the day is generally closed with a ball in the open air under the cocoa-nut trees. The young people dance, while their seniors look on and criticise or commend. They will often keep up the dancing, to the monotonous music of their drums, until the small hours of the morning.

Strangers are saluted by putting the hand to the nose and then to the stomach. Shaking hands and kissing are alike unknown; but many among the inland tribes welcome their friends by chucking them under the chin. It is considered bad manners to omit, on meeting a

friend, to ask him where he is going, or to deliver a message to a superior standing. Among some of the inland tribes the custom prevails of smoking, instead of drinking to one's health. When the bamboo pipe is filled with smoke and ready for inhaling, the man shouts out the name of the friend he wishes to honor, before taking a whiff; he then passes it on to the next, and he shouts out in the same way, and so on all round the circle. The habit of smoking seems to be original, not borrowed. The practice of chewing the betel-nut is still more prevalent.

The government is patriarchal, the chiefs ruling over villages which are independent of each other, holding their office by inheritance, but having to maintain themselves in it by their energy and force of character. The son of a chief who is weak-minded and a fool soon sinks to the common level; while a commoner, who is strong and brave, with greater mental power than his fellows, comes to the front and is soon recognized as a chief. The moral condition of the people is deplorably low. All are thieves, seeming to feel no sense of shame in stealing; and we were looked upon as great wonders by the natives because we did not steal, and our honesty was always mentioned, in any description of us, as one of our peculiarities. Human life is invested with no sanctity, but the distinction the men are most proud of is that of having shed human blood. No one has a right to be tattooed until he has killed some one, and the right is sought as a privilege.

The natives are not often on peaceful terms with their neighbors, though their warfare is not deadly. They are exceedingly suspicious and distrustful. They never sleep without their weapons within reach, and never go out without spear or club. They came to our house readily enough at first, but the slamming of a door or any unexpected noise was enough to bring them to their feet.

The family tie is strong and lasting. Men live virtuously with their wives and children. Polygamy is not common, although it is thought to be proper for chiefs. The burden of labor is fairly divided between the men and the women; and the women insist upon carrying wood, water, and burdens, as of their rights.

The people seem to have no religious ideas, no idols, no idea of a God as a supreme being or a good being. Their only religious ideas consist in a belief in evil spirits, toward whom they live in slavish fear, but without any idea of propitiating them by sacrifice or prayer. They believe also in the deathlessness of the soul, without having any definite ideas as to its abode or condition. Much difference, however, prevails among the different tribes as to the development of ideas of this character. Among some there seems to be a vague recognition of a Great Spirit who gives them plenty and other blessings; and to the west of Port Moresby, in the district of Elema, are idols and idol-temples, but the natives there belong to the darker-colored race.

I was glad to read, in the report of the Geographical Section of the British Association meeting at Sheffield, that several travelers from Africa had said a good word for the cannibals. I should like to do the same for the cannibals and non-cannibals of New Guinea. I have visited a great many villages, in most of which no white man had been before; my wife and I were for a time the only Europeans living on the island, but I have never been molested anywhere. We are known along the coast as the bearers of peace. As I went through one of the villages for the first time, a native from another ran before us and shouted, "These are the *maino taunas* (the peace-men), who bring and make peace everywhere!" Confidence begets confidence, and there is a wondrous power in human kindness.

SANITARY RELATIONS OF THE SOIL.*

By Dr. MAX VON PETTENKOFER.

I.

I AM well aware that I have chosen no new theme when I assume to speak of our soil and its relations to our health. It is, on the contrary, very old—for Hippocrates wrote two thousand years ago on air, water, and earth in their hygienic relations—but there are old subjects that are always awakening a new interest, and always appear fresh when considered in a new light or from a new side. To these eternally fresh subjects belongs that of the ground on which we stand and live, on which we are born, and in which we are to be buried. Since mankind has comprehended the idea of health, sickness-giving and health-promoting properties have been ascribed to the locality, which has been regarded as consisting of air, water, and earth; but the seat of that which makes sick and makes well has been supposed to be more in the air and water and less in the soil; that is, it has been conceived that a place might have its own air and its own water which we have to use directly in breathing and drinking, while we could be independent of the soil, on which we only tread. The local air could, however, hold the first place in hygienic regimen only as long as it was not known that the average velocity of the atmosphere over the surface of the earth is three metres (or ten feet) in a second, and that, even when we feel that it is perfectly calm, the air is moving at the rate of a half-metre (or twenty inches) in a second. A real stagnation of the air, even in deep cloves and valleys, or in the narrowest streets, is not to be spoken of; the air is rather to be conceived as undergoing a constant

* An address delivered before the Association of German Naturalists and Physicians, at Salzburg, September 18, 1881.

change of place. And if it has properties or contains matters in one place which are not remarked in a neighboring place, they can not originate in the air itself, but must be derived from the locality from which they are communicated to it, and are then carried away in the free atmosphere, to disappear by dilution and other processes.

The same is the case with the local water. All the water that we drink on the earth falls from the sky, and is everywhere of precisely the same composition. Only when it penetrates the soil is it changed by taking up matter which is derived from the ground through which it flows, a fact that was mentioned by Hippocrates. And the local admixtures disappear from water, partly by dilution, partly by chemical changes, just as they do from the air; only in a lesser degree and more slowly, because water is present in the soil in smaller quantity and moves more sluggishly than air. This purification of the water takes place not only during its continuous retention and movement in porous soils, but also in open river-beds and streams. Brunner and Emmerich have drawn water from the Isar at numerous places between the mountains and the mouth of the river at the Danube, on the same day, and have found it essentially alike everywhere, although the stream receives considerable admixtures from the towns on its banks.

What is there that does not fall into the Elbe in its course from Bohemia down to the sea? Yet filtered Elbe water is considered a pure drinking-water at Hamburg and Altoona.

The river Trent receives, before it reaches Nottingham, the sewer-water of two million people dwelling on its banks, amounting to at least five hundred thousand gallons a day, yet its waters at that city are clear, sweet-smelling, and chemically free from injurious constituents.

At Paris, the collecting sewer of Clichy pours a great stream of blackish water into the gently flowing Seine below the bridge of Asnières, by which the river is so fouled that neither fish nor plants can live in it; but at Meulan, a few miles below Paris, every trace of impurity has disappeared from the stream.

When the air and water at any place are contaminated, the contamination does not proceed from any combination or decomposition of those two elements, but from qualities of the place, and they soon purify themselves again. An impurity cleaves longest and most tenaciously to the soil, which suffers no change of place, like air and water. While formerly we esteemed the hygienic value of the air first, of the water second, and of the soil third, we should now reverse the order.

The influence of the soil upon the health of those living upon it is brought out very plainly during the prevalence of epidemic diseases. That malarial diseases, like intermittent fevers, originate from the soil, is already accepted; and the more exact studies in recent times of the manner in which cholera, abdominal typhus, yellow fever, and the plague are spread, has convinced many that these diseases, also, which

were formerly considered independent of the soil, because their specific germs are communicable and are actually communicated by human intercourse and trade, are still in some way connected with it, although the nature of the connection is yet to be found out. The explanation of the frequent, sharply defined local limitations of cholera and typhoid has been sought first, in influences not of soil but of water and air, to which the germs of disease have been imparted from men ; but a clear and impartial examination of the local prevalence of these diseases in circles of greater or lesser extent has now furnished evidence that in many cases air and water can no longer be maintained to be the causes of the localization, but that the sources of the epidemic must be sought in the soil.

In the occurrence of cholera on ships at sea, where any influence of soil would seem to be absolutely out of the question, that influence often makes itself apparent in a striking manner by the fact that only persons who have come from certain places are attacked, while other persons on the ships do not even have a diarrhœa, although they are all the time with the sick, and use the same food and water and air. Ships at sea may be considered as in themselves safe from cholera ; usually sickness brought upon them in individual cases dies out ; and it is regarded in seafaring practice as an excellent prophylactic measure to go to sea, taking the sick along and breaking up all communication of the men with the infected port or shore. Exceptional cases of epidemics breaking out on ships can not be regarded as arising from contagion from person to person, but always from previous communication of the ship or its crew or passengers with some place infected with the disease.

Not less plainly and frequently is the real influence of the soil shown in inland regions and towns that enjoy immunity from cholera. Permit me to bring forward as a well-known but pregnant example the great manufacturing and commercial city of Lyons, in Southern France, which has constantly maintained with impunity the most active intercourse by sea and land with cities infected with cholera ever since the disease first appeared in Europe. Often as cholera-epidemics have prevailed in Paris and Marseilles, the disease has never yet gained an epidemic footing in Lyons, which lies right between those two cities, notwithstanding many cases have been brought into it from without. Even in 1849, when the city was in revolt and was besieged and occupied by cholera-infected regiments from Paris and Marseilles, and the civil population were suffering from disorder, want, and misery of every kind, the disease did not spread.

The immunity of Lyons is now a generally recognized fact in France, and the city derives a considerable profit from it ; for the rich people of Paris and Marseilles, whose circumstances permit it, are accustomed to flock to Lyons like sheep as soon as cholera breaks out in their homes, and readily pay a good price for the patient hospi-

tality of the people. Formerly, if one asked in Lyons why the city was so happily and so strikingly spared, he would not be referred to the unusual cleanliness and comfortable life of the common people, nor to the splendid drinking-water, for, before filtered Rhône water was introduced in 1859, this was very bad, but to the air, whose circulation through the confluent valleys of the Rhône and the Saône was so lively that it was always master over the imported cholera-poison, and would not let it develop. But if we compare the velocity of the wind as observed at the Lyons meteorological station with that of other places much afflicted with cholera, we shall not find the slightest difference in favor of Lyons. The plain of Languedoc, over which the *mistral* blows so often, unroofing houses, uprooting trees, and destroying ships in the very harbor of Marseilles, is not seldom visited by epidemic cholera. Later investigations show that nothing is left with which to explain the immunity of Lyons but the condition of its soil. Apart from the size of the city, this immunity is not more striking—it is, in fact, not so striking—than that, for example, of Versailles, where, notwithstanding a constant daily and hourly communication with Paris, cholera has never broken out in an epidemic form. Decaisne has shown that the condition of the soil only can be regarded as bearing upon the immunity of this place.

Analogous facts may be found wherever the spread of cholera or typhoid is earnestly investigated. The beautiful city of Salzburg, which is now so hospitably entertaining the Association of Naturalists and Physicians, belongs to the number of fortunate cities that have so far been spared cholera-epidemics, notwithstanding numerous refugees from cholera have collected here when the disease prevailed in Austria and Southern Bavaria; among whom cases have occurred without the infection passing over to the city. Only in the winter of 1873–'74, when a severe outbreak of cholera occurred in the prison establishment at Laufen, did weak signs appear in Salzburg, showing that at least certain quarters of the city were not absolutely and invariably protected against cholera. So Lyons was made aware once, in 1854, that the whole city was not insusceptible to it. The Lyonnese were not willing to acknowledge this, for they had boasted too much of their immunity; but they asked, What do a few hundred cases of cholera in fifty years amount to in comparison with the total population (400,000 souls) of the city? We should not treat the subject in this way, but should rather ask, How many inhabitants has the part of the city which, even if it was only once, had a considerable number of cases of cholera? and then the reply can not be evaded that the suburb of Guillotière suffered from a decided cholera-epidemic in 1854. This once-occurring epidemic was associated with an equally rare abnormal drought and a long-continued low stage of water in the Rhône, such as had not been observed since 1826. So Salzburg might at some time be visited with cholera, at least here and there, if the sky should obstinately keep

its gates closed for an unusually long time, and the disease were in its neighborhood.

The reports of the cholera commission for the German Empire contain a large number of proofs of the influence of the locality, particularly of the soil, among which I might especially mention the reports of Gunther on the spread of cholera in the kingdom of Saxony, and of Pistor on the government district of Oppeln. Both these investigators, not satisfied with considering only the last visitation of cholera in 1872–'74, have also included within the circle of their inquiry all the outbreaks that have come to knowledge since the appearance of the disease in Europe in 1832. The confirmation of the localistic theory of cholera and other epidemics can no longer be put in question; and, if it were the only result reached by the German cholera commission, the money appropriated to the investigation would have been well spent.

We may now ask, What can there be in the soil that can exert so powerful an operation for good or evil upon our health? To this question, so far as concerns injury to health, the answer may be returned that, in all probability, the property is derived from the minute organisms or their products, of which many million individuals can be put within the area of the head of a pin, and which inhabit the porous soil from the surface down to a great depth—organisms which are capable of being injurious or harmless, or even useful to us, as we are already acquainted with injurious and harmless and useful plants and animals. They have heretofore been invisible to us, having only just been brought to knowledge, in the course of recent investigations in vegetable and animal physiology and pathology, by means of the microscope and experimental cultivation. A prominent vegetable physiologist, Naegelli, has accurately and clearly described them with direct reference to their hygienic significance in his well-known work, "Die niederen Pilze in ihren Beziehungen zu den Infectionskrankheiten und der Gesundheitspflege." Their mysterious presence recalls the ancient belief in invisible spirits that were accustomed to rise out of the earth, float in the water, and cast gloom over the spots haunted by them. Naegelli called a soil that produces or favors epidemics a disease-bearing (*Siechhaft*), and its opposite a healthful (*Siechfrei*) soil. We must not conclude that only a locality of the former kind harbors molds and similar lower organisms, and one of the latter kind does not, or that these organisms reach us only from the former and not from the latter; on the contrary, they are always present everywhere. If they sometimes appear deleterious, at other times harmless, the conviction is forced upon us, either that the same species do not occur universally, or that the same species assume different properties at different places, under different circumstances, and at different times; that is, that they are only here and there and occasionally poisonous. If either is the case, the medium in which they

live must exercise a very great influence upon them; and, so far as this medium is the soil, we have to investigate the conditions which it offers for the growth of these organisms and the communication of them to men. It must be admitted that mycology has so far given us very little light on this point, and many problems respecting it are still waiting to be solved; but it is already well established that hygiene as well as agriculture has much to do with the ground.

Some advance had already been made in the investigation of the hygienic relations of the soil before molds were mentioned as causes of infectious diseases. The simple observation that such diseases occurred or did not occur under certain conditions of the soil was enough to provoke this. It had already become possible, without knowing the more immediate causes, to make an unhealthy soil healthy. The best-known examples of this kind are given in the cases of intermittent fevers and malarial soils, in which the deleterious properties have been wholly or partly remedied by drainage and the drying up of the subsoil, and the fertilization and cultivation of the surface. Tommasi-Crudelli has a remark of the highest interest in his recent work on the malaria of Rome and the former drainage of the Roman hills, to the effect that the ancient Romans suffered much less from fevers than the Romans of after-times and of to-day. The archæologist De Tucci having called attention to some underground canals of a peculiar kind, called *cuniculi*, in the Roman hills, Tommasi examined them, and found that they were designed exclusively to drain the hills, and that they were now choked up and inoperative. Formerly, he thinks, they were so familiar that the ancient Roman writers did not think it worth while to speak of them; they passed into forgetfulness during the irruptions of the barbarians and the middle ages, and have now had to be discovered anew.

Measures directed against other infectious diseases that depend on the soil have not been without results, although the specific causes of the diseases are not known.

What are the conditions of soil favorable to epidemics?

It is an old experience that certain infectious diseases have their favorite seats in the so-called alluvial soils, in lands subject to overflow. Alluvial soil consists chemically and geognostically of substantially the same mineral matters as the compact mountain-masses, from the disintegration of which it has originated—except that its physical aggregation is essentially different; and it is distinguished from rock-soils by the great permeability for air and moisture arising from its great porosity, that is, from the spaces in which air and water, as well as organic matters, can find place. There are also kinds of rock which are very porous, and their behavior is not materially different from that of alluvial soils, as is shown by the cholera-epidemics in the Island of Malta.

In common life we can hardly conceive the extent of the porosity

of the soil on which we dwell. Heavy, towering buildings often stand on a soil which is filled to the extent of a third of its volume with air. The investigation of ground-air has just begun, but it has already surprised us with some unexpected revelations. Ground-air is distinguished from the air that passes over the surface by the higher proportion of carbonic acid it contains, which increases, as a rule, with the distance from the surface, and to which our springs owe their charges of that gas. This carbonic acid is chiefly derived from organic matters and organic life in the ground, with which it increases and diminishes. Air brought by Zittel from the dead dry soil of the Libyan Desert, sealed in glass tubes, showed no larger proportion of carbonic acid than the free superficial air, but the ground-air from a palm-garden in the oasis of Farafreh yielded much carbonic acid. That this gas is mostly derived from organic changes is shown from the investigations of Fleck, Fodor, Wolffhügel, Möller, Wallny, and others, who found that the proportion of oxygen in ground-air was lower, while that of carbonic acid was higher, than in free air.

That the air in the soil does not become stagnant, but is always in motion, though sluggish, not only follows from physical laws, but may be easily proved by experiments and observations. Our houses are aired or ventilated in no small degree by the ground-air. Renk has been inquiring, with the aid of Recknagel's differential manometer, whether the air flows from the ground into the house or from the house into the ground, and has found that through most of the year the draft is from the ground into the house. He has also found that the ground-air, which is sucked into the house, brings, dust with it, and other observers have shown that the same air also carries germs susceptible of development in suitable solutions.

It is thus easy to see how the soil affects our health without our having to eat it; the ground-air plays the part of an always ready intermediate agent, so far as concerns the molds. In this light it is easily seen why some houses sometimes have to suffer so badly from certain conditions of the soil, especially when they are badly ventilated. The movement of the air in a close house is many thousand times less active than where the circulation is free; and the air entering into the house suffers correspondingly less dilution than that passing into the free atmosphere, and leaves in it much more of what it brings up from the ground. While the house is heated during the cold season, and at night in the summer, while the air within-doors is warmer than the surrounding out-door air, the houses act as draught-flues, and suck air out from the ground as if they were cupping-glasses set over it. Experience has long taught us that it is most dangerous to sleep—that is, to pass the night—in such noted fever regions as the Pontine Marshes.

Many persons believe that the ground-air is an object whose existence is still pre-eminently theoretical, and that its practical influence

is exceedingly remote. It does not present itself in this light to the physician who has had to deal with it. I am reminded of what the chief staff physician, Dr. Port, has remarked, as if by intuition, on the etiology of abdominal typhus, with immediate reference to military hygiene, and its bearings on the construction of barracks and camps. He says: "If we consider the danger to which the inhabitants of a disease-bearing soil are exposed by leaving their houses without protection from the soil, I might say by putting them on the ground barefooted, and, if we reflect that our most imposing palaces labor under this partial nakedness, we must of necessity receive the impression that there is some lack in our civilization. We have in this respect not only not excelled the most primitive constructions of the childhood of the building art, but have fallen behind them in a very important matter. We have no reason, from the hygienic point of view, to look down disparagingly on the pile-dwellings of some foreign races and the mud huts which our peasants still live in here and there: both of these classes of people, although in very different ways, have respected, in building, a hygienic principle that has escaped our architects. They have made their dwelling-places independent of the ground, in the former case by putting under them a grating of piles admitting a circulation of air; in the latter case by isolating the hut by means of a plaster floor. The superiority of these primitive dwelling-houses over our modern buildings can not be made to appear more clearly by any other example than by the sketch which Dr. Hirsch has given of an outbreak of cholera on the estate of Herr von Winter, chief health-officer of Dantzic:

"Nine houses stood in a group in front of the manor-house of the estate, and were inhabited by the farm-servants; seven of them had been rebuilt in timber with brick fillings, and furnished with cellars, which were perfectly dry; their ground-floors were lined with deal, were dry, airy, and kept clean; the manure-heaps were arranged in the manner that is common in rural districts. Two of the houses in the group had not been rebuilt; they were old mud huts, with low stories, without cellars; the rooms were not boarded up, but only plastered; and their condition seemed on the whole much more unfavorable than that of the others, while the manner of living of their inhabitants in other respects was in no way different from that of their neighbors in the modern cottages. About one hundred and fifty persons lived in all the nine houses. A woman, suffering from an attack of cholera, was taken into one of the new houses; three days afterward the first cases of sickness appeared in the neighborhood of this house, and the disease quickly spread to all the houses except the two old huts. The inmates of these houses had the same intercourse with their fellow-dwellers on the premises as the latter with each other; yet, while seventeen persons (or fifteen per cent of the whole number) in the seven new houses were prostrated, not a case of sickness occurred in the old huts. The

exemption of the latter was attributed to their being isolated from the ground by means of their plaster floors. The change of the other cottages into modern dwellings, with exposed foundations, was hygienically a reformation for the worse. We frequently commit the mistake, in carrying out our ideas concerning the salubrity of a house, of confounding hygienic considerations with those of comfort."

Dr. Port brings forward other facts speaking for the influence of ground-air, and summarizes his view in the remark that he regards "a proper treatment of the soil as the first hygienic consideration, the chief prophylactic measure against certain infectious diseases, as the means by which we may make houses, barracks, tents, etc., dwelling-places free from disease. . . . From such dwellings we need not flee on the appearance of epidemics, but in them can bid defiance, as from a fortification, against disease; of such a dwelling we may say with truth, 'My house is my castle.'" It is very much to be desired that the building art could be turned, at least experimentally, in the direction indicated by Dr. Port. Practical hygiene is as little capable of being advanced without experiments as any other art; and where individuals can not experiment, the state should step in, in the interest of the public weal, and provide the means for answering important questions.

PROGRESS OF COPYRIGHT LAW.

By BENJAMIN VAUGHAN ABBOTT.

WHATEVER progress has been made in the law of copyright, during the past year or two, is seen in decisions of courts. In the realm of legislation no positive progress has occurred. A project of a general revision of the English enactments, which has been several years in preparation under parliamentary authority, has been fully completed and submitted for debate and enactment; and a very interesting and important negotiation for an international treaty has been carried far toward successful completion. But no actual results are yet achieved by either of these efforts to improve the law.

What literary compositions may be secured by copyright? The claim of a "law-reporter" has been sustained. For more than a century it has been customary to publish reports of the decisions of courts, in form somewhat peculiar and characteristic. The main thing to be given is, of course, the opinion of the court; and this, by general opinion, can not be copyrighted in the reporter's behalf; it is the official work of the judge, and is public property; or, at the least, it is not the reporter's property; whether the government employing and paying a judge can, by copyrighting reports, maintain a literary property in his official opinions, is a question not yet decided. But a

report contains matters auxiliary to the "opinion," the preparation of which involves much literary labor and skill; such as a "syllabus" of the case, or brief statement of the points of law decided; a narrative of the facts involved in the trial; a condensed statement of the arguments; and, perhaps, a foot-note collating other decisions germane to the subject. A majority of existing law reports have been compiled by the reporters in the expectation of taking out a copyright and realizing a profit upon sales. The practice of paying a reporter a salary, now very common, is of recent introduction. Lately complaint was made on behalf of an official law-reporter who had no distinct salary, but compiled the reports relying on the copyright as his compensation, that a rival publishing firm were issuing a condensed edition. The publishers argued that the reporter's work was official, and not a subject of copyright. The judge said he thought an officer enjoying a salary for his work probably ought not to claim a copyright, but one who worked for the copyright as his compensation ought to be sustained in it. The publishers also showed that they had instructed their editors to draft new head-notes and narratives of facts. The judge said he could scarcely see how new editors could in fact compile these parts anew unless they consulted the original records. It was not shown that they had done this; moreover, the judge's comparison of the two books led him to think that the editors had in fact used the reporter's work to a considerable extent. The decision was in favor of the reporter's claim. It is noteworthy that a decision rendered half a dozen years ago, though published recently, declared that a reporter could not claim copyright in head-notes furnished to him by the judges as part of their official duty.

Upon the death of Lord Beaconsfield, the London "Times" published an elaborate memoir. Some one reprinted it in a penny pamphlet. Of this the proprietor of the "Times" complained; but the publisher of the pamphlet said that he had the right to issue it because the "Times" was not copyrighted. Now, the copyright laws do not mention newspapers by that name; they allow copyrighting "books"; when newspapers are copyrighted, it is done upon the idea that the term "book," liberally understood, includes a newspaper. For the proprietor of the "Times" it was argued that a newspaper like the "Times" is not a proper subject of copyright; and that, there being no copyright law available for articles in newspapers, the publisher has "a common-law right"—a natural property, independent of statute—by virtue of which he can forbid any one else from reprinting them. There is said to be a former English decision to this effect. But the judge decided, in respect to the Beaconsfield memoir, that the "Times" newspaper can be copyrighted, and that it should have been, in order to sustain the claim made. He sanctioned the little pamphlet.

Many of our readers know the two books "Monitor Post-Office,

etc., Guide," and Mackey's "Shippers' Guide." The proprietor of the "Monitor Guide" sued Mr. Mackey for violation of copyright. The judge said that such guide-books are a proper subject of copyright; but that the right was not so broad and full as the plaintiff claimed; it did not forbid Mackey from collecting similar information to that given in the "Monitor Guide," about post-office, railroad, express, and telegraph business, or from arranging and exhibiting it in much the same general ways, but only from copying material portions of the "Monitor Guide."

Recent decisions on the question whether books designed to be used in a *quasi*-mechanical way—ruled account-books, bond-registers, and the like—should be copyrighted or patented, were narrated in an article in the July number. Nothing new on that topic has transpired, except that a patent has just been sustained for an improved "check-book."

Does the copyright law sustain property in the mere title of a book? The tendency of thought is that the law of trade-marks affords such protection as there is for a title, as distinguished from the body or contents; that the purpose of the copyright law is to secure the exclusive right of publishing the substantial work, and that it protects the title only as being a part of the work. But it can not be said that this has been sharply decided. When the directory for London was established, which was about seventy years ago, the necessary information was gathered or furnished by post-office clerks; hence the book was called, naturally enough, the "Post-Office Directory." In later years the post-office aid was discontinued; the proprietor of the enterprise continued, however, to issue the book annually, on information gathered by his own canvassers. He adhered to the familiar title, registering the successive volumes, under the copyright laws, as "Post-Office Directories." At length a rival commenced a directory for Bradford, which lay within one of the districts covered by one of the issues of the old directory; and this rival called his work also "Post-Office Directory." He has been sued; but both courts held that he was not violating copyright; nor, indeed, the trade-mark law.

Miss Braddon wrote a novel to which she gave the name "Splendid Misery," and sold it to the London journal called "The World," conducted by Mr. Edmund Yates; and "The World" began publishing it as a serial story. This occurred in 1879. Before long the proprietor of "Once a Week" entered a complaint, saying that in 1874 he had purchased and published in his paper a novel by C. H. Hazlewood (which had been duly copyrighted), also under the title "Splendid Misery." He did not suggest that Miss Braddon's story imitated Mr. Hazlewood's; the only question was whether he had an exclusive right to the title, by virtue of the copyright law. The vice-chancellor thought his claim good; and, indeed, there is an earlier decision to much the same effect. But Miss Braddon's publisher learned that, as

long ago as 1801, a novel written by still another author had been published under the same title—"Splendid Misery." Partly on the ground that this publication had rendered the title common property, so that now any one may use it, the Court of Appeal decided in favor of Miss Braddon's publisher. Apparently, however, the judges consider the general English law to be: 1. A title has no special protection by the copyright law; that protects it only as any other part of the book; 2. Another person who uses the same title only, without either imitating the book or deceiving the public, can not be stopped by a copyright suit; 3. Appropriating a title under circumstances which show an intention to attract people to buy the book under the supposition that they are getting another well-known one—as, if one should publish an anonymous, inferior story under the title "Vanity Fair," for the purpose of leading buyers to think it was the celebrated story by Thackeray—is a fraud on the public, which may be published or stopped, independent of copyright law. But the question of holding a title by force of the copyright law should, perhaps, be deemed an open one in England; two vice-chancellors have decided that it may be; but the judges of the Court of Appeal have said that they do not think so; this was said, however, in a case in which the facts did not enable them to make an authoritative decision.

In America, when the copyright of "Irving's Works" expired, recently, a rival publisher issued a volume of selections, using the same title—"Irving's Works." The former publisher, though he could not complain of the publication of the substance of the volume, did bring his suit to forbid using the title; it was, as he claimed, his trademark. But the judge said that the public were not misled; the selections comprised in the book were genuine writings of Washington Irving; and, now that any one may publish Irving's writings, he has the right to style them "Irving's Works."

There has been a decision on a matter very germane to copyright, the affixing of an author's name to a book. The story of the plaintiff, who was an American publisher, was, that he devised a new plan for compiling illustrated guide-books to towns, according to which a Mr. Kenny prepared several such books relating to towns in America. They were known as "Kenny's Guide-Books." Subsequently the publisher agreed with Kenny for the use of the latter's name upon a guide-book for London; and he employed Mr. Marsh (against whom the suit was brought) to write the London book. The engagement was on the distinct understanding, so the publisher said, that Marsh's name would not appear as author. The publisher, however, announced the book as being "by D. J. Kenny (assisted by John B. Marsh)"; but Marsh, then, although he had drawn his pay for preparing the work, withheld the manuscript. The publisher asked the court to compel him to deliver it. The author, Marsh, denied positively that he ever

agreed that the book should be published without his name, and said that his reason for withholding the manuscript was, that styling the book on the title-page as being "by D. J. Kenny" would be a fraud on the public, since Kenny had taken no part in preparing it. The court decided in favor of the author. This is as much as to say that a writer shall not be compelled to furnish manuscript which he withholds because he knows it will be published under another man's name in a way to deceive the public; but whether an author has a legal right to have his own name appear on a book he has sold outright is another question.

Dramatic copyright is a fruitful field of litigation. To protect a play by any legal methods is difficult, and the laws having that aim have not been so distinctly and judiciously framed as they might be. Several suits have been brought, in this country, within the past year or two, to protect noted plays. An English suit, which reached an authoritative decision in the House of Lords, arose upon two rival dramatizations of Eugene Sue's novel, "The Wandering Jew." This novel was dramatized in France quite early after its publication, and Englishman number one prepared a play described as an "adaptation" of this French play. He, however, introduced two striking scenes: one displaying the wandering Jew strolling in the Arctic regions (real icebergs and a lime-light) and beholding, in a mysteriously managed vision, the future perils and sufferings of his descendants; the other exhibiting the final triumph over the enemies' machinations, and introducing the figure of the Jew in the background, under brilliant red lime-light. In the French play, these matters were not scenically represented, but were described in a prologue and epilogue; perhaps because the devices of stage carpenters and property men were not sufficient, fifty years ago, for such spectacles. Englishman number two also dramatized the story, independently of and differently from the play by Englishman number one, except that he took from the latter's play the points of bringing these two matters into actual representation, instead of leaving them to prologue and epilogue. For this he was sued. But the courts, including the House of Lords, held that taking the two scenes was not enough, under the circumstances, to constitute an infringement. Copyright of a play is not infringed unless some substantial, material part—more than a new mode of representing a couple of matters not really essential to the unity of the plot—has been taken.

Another English decision has said that, when two or more persons own together the copyright of an opera or drama, one can not represent it or license a manager to do so, without consent of the others.

In respect to musical compositions, decisions have been made in England upon the right to publish the songs "Kathleen Mavourneen" and "Dermot Asthore," and the opera "Vert-Vert"; but they turned on the bargains the parties had made, and do not explain copyright

law except that they clearly show musical compositions to be fully entitled to the protection. An odd case occurred in Pennsylvania, which was thus narrated in the "New York Times": "A publisher copyrighted and brought out an 'arrangement,' made by an American musician, of a popular French waltz, christening it 'Manola Waltz.' A competitor republished it with scarcely any changes, and when the first publisher complained, 'Your waltz is only a copy of mine,' he answered, 'Yours is only a copy of the Frenchman's.' The judge said that a man need not be an original author—the sole creator of the work; the first publisher could fairly get a copyright for his arrangement'; and the second one had no right to reprint that arrangement, though he might have made a new and different one."

Pictures have given rise to several decisions. Some manufacturers of earthenware for the Cuban market ornamented their ware with a portrait of the Captain-General of Cuba, surrounded by a wreath; this portrait was copied from a photograph of the general. Also the father of an attractive young lady had her portrait painted in "character," representing her as a young girl walking on the sea-shore, shoeless and stockingless, and carrying a spade and basket; this picture he copyrighted and had it engraved for publication as "Going to Work." Lawsuits were brought to protect these two copyrights. The decisions apparently take the view that a picture of a living person is not a proper subject-matter of copyright; that the law will not protect a "design," the chief element of which is a portrait, while the additions or accessories are but trivial. In a lawsuit over a book "with illustrations by John Leech," it appeared that the designs were drawn by Leech himself, upon the blocks; and he retained the copyright; the publishers, apparently, however, furnished the wood; and, when a controversy arose, they made the law point that, though the designs possibly belonged to Leech, the blocks belonged to them (the publishers), and they meant to keep them. The court said that, considering the way in which the parties had dealt, also that the wood was worth next to nothing in comparison with the designs, it was fitting that the publishers should surrender the cuts. In America, a publisher who was sued for violating the copyright of a picture, proved that, in preparing the chromo which he sold, he had not copied from the picture copyrighted in this country, but had followed an English original; and the court pronounced this a good defense. Copyrighting a picture forbids another person from copying it, but does not forbid copying a picture like it from foreign publications, or designing one anew.

More interesting than either of these is a decision involving the famous picture originally painted by Millais, about thirty years ago, known as "The Huguenot." From this painting an engraving was taken, which was duly copyrighted, and has had a wide sale. More lately the publishers of the London magazine "Bow-Bells," in a Christ-

mas supplement, issued a chromo-lithograph pattern for Berlin-wool work, embodying this picture. When sued, they said that they bought the pattern in Germany; they did not, however, dispute that it had been copied from the engraving, but claimed that copyright in an engraving only protects the proprietor from competition of engravings and other prints adapted to be sold and used as engravings are; that is, as works of art to please the eye. And the Court of Appeal so decided. The purpose of any kind of picture intended to be hung as an ornamental work of art, and that of a mere pattern to be used as a guide for an embroiderer or artisan, are so different that the pattern can not be called a copy of the picture, in the sense that it violates the copyright law.

Recent decisions have not been particularly favorable to maps and charts. In America the compiler of "insurance maps" devised a novel system of colors and signs, explained by a key, enabling a person to see at a glance the character of the buildings and other facts about the property important with reference to insuring it. He copyrighted these maps. An imitator prepared maps of Philadelphia on the same plan, and using like colors, signs, and key. The Supreme Court said that this was no infringement. A copyright gives the exclusive right of multiplying copies: to infringe it, a substantial copy of the whole or of a material part must be produced. Now, maps of Philadelphia can not possibly be deemed copies of maps of New York. Scarcely any map is published on which some arbitrary signs explained by a key are not used; but copyrighting the map does not secure an exclusive right to the signs and key for all other maps. A dealer in zinc paints contrived an advertising card bearing bits of paper painted in colors and serving to exhibit the hues of the paints sold by him; and this card he copyrighted as a chart. The judge said that it was not a chart, nor the subject of copyright; and that, if it were, a rival dealer's similar card using colored papers to show what paints were sold by him would not be an infringement, because it was not a copy of the information conveyed by the first card. A print-dealer contrived pattern-prints of balloons, hanging-baskets, etc., bearing printing as a guide for embroidery, and cutting-lines, showing how the paper might be cut and joined to make the different parts fit together. The judge said that things of this nature are not the subject of copyright.

A recent decision in favor of a lecturer's right to control publication of addresses which he does not print but retains for repeated oral delivery, is narrated, in an article entitled "Medical Lectures and the Law of Copyright," in the "New York Medical Journal" for June last. Rumor says that the question is to be raised again in a suit by Colonel Ingersoll.

London and New York have each a "Coach-makers' Journal"; and the New York editor copied an article from the London paper. Thereupon the London publishers, finding that a news-agent there was im-

porting and selling copies of the American paper, prosecuted him. He argued that it was impossible for him to know, when ordering books from America, that they contained English extracts, and that he ought not to be punished for simply importing and selling books in the ordinary way of business. But the decision was, that an importer is bound to ascertain; or, if he imports without inquiry, he takes the risk that there may be something in the books which he will not be allowed to sell. A more lenient view of a somewhat similar question was taken in an American decision; it held that a partner or employer is not chargeable with a statute penalty for acts in violation of copyright done without his authority or knowledge by his partner or agent. Some intention to violate the law must be shown, according to this case, to sustain a prosecution.

VOLCANIC PRODUCTS.*

THE most abundant of the substances ejected from volcanoes is steam, or the vapor of water, which issues in prodigious quantities during every eruption. With it frequently appear numerous other volatile matters—the acid gases, hydrochloric, sulphurous, carbonic, and boracic acids; sulphuretted hydrogen, hydrogen, nitrogen, ammonia; the volatile metals, arsenic, antimony; and some other substances not usually volatile, but which are nevertheless easily carried away in fine particles when a current of steam is passed over them. These various substances react upon each other, and give rise to the formation of many new compounds. Deposits of sulphur result from the action of sulphuretted hydrogen and sulphuric acid on each other; hydrochloric acid forms, with the iron in the rocks, the yellow ferric-chloride which coats the vents, and is often mistaken for sulphur. The iron, lime, and alkaline materials of the rocks are converted by the acids into soluble salts, which, being washed away by the rains, leave a white powdery deposit of silica that so much resembles chalk that travelers have been led to describe islands in which it appears very abundantly as being composed entirely of that substance. Some of the gases, as hydrogen and sulphuretted hydrogen, are inflammable, and may sometimes be seen at night playing over the fissures in faint, lambent flames, occasionally brightly colored with metallic salts. These transient flames are not, however, to be confounded with the red, glowing light which is commonly called "volcanic flames," but which is not really a flame, only the reflection in the vapors of the glowing mass in

* Volcanoes, what they Are, and what they Teach. By John W. Judd, F. R. S. With Ninety-six Illustrations. "International Scientific Series." New York: D. Appleton & Co., 1881.

the crater beneath. Some of the volatile products of volcanoes are of economical value, like the sal-ammoniac, sulphur, and boracic acid of Vulcano, which have given rise to extensive chemical works.

Solid substances are ejected and accumulate around the orifices, where they frequently form large mountains. They are fragments of rock torn from the formations through which the eruptive stream passes—crystallized minerals, or matters which, derived from sources far below the earth's surface, issue in an incandescent or molten condition, and to which the name of lavas is properly applied. The lavas are composed of the silicates of aluminium, magnesium, calcium, iron, sodium, and potassium in different degrees of combination or mixture. Oxygen, in silicic acid or in a metallic oxide, makes up nearly half the weight of all of them, the metalloid silicon one fourth, and aluminium one tenth of the most of them. Silica or silicic acid—rock-crystal or flint—is present in proportions varying from one half to four fifths of the whole mass. Those lavas in which silica is present in larger proportion are called "acid lavas"; those in which the base is in greater proportion, "basic lavas." Between these are the "intermediate lavas," in which the proportion of silica is lower than in the acid lavas, and the proportion of bases is lower than in the basic lavas. Of the five great groups into which geologists have divided the lavas, the rhyolites are acid, the basalts are basic, and the trachytes, andesites, and phonolites are intermediate.

The structure of lavas can be more clearly ascertained by studying them in the condition of transparent or semi-transparent slices under the microscope. Most of them are made up of crystals of different minerals, varying in size from those which are hardly visible to the naked eye to those of an inch or more in length. Others appear glassy in structure. Under the microscope, they are shown to be made up of two kinds of materials, a base or ground-mass of a glassy character, and distinct crystals irregularly distributed through this glassy base, like the raisins in a cake. In some cases the vitreous part makes up the whole mass of the rock; in others smaller or larger numbers of crystals are seen to be scattered through a glassy base; while in others again the crystals are so numerous that the presence of an intervening vitreous ground-mass can be detected only by the aid of the microscope. When slices of the glassy materials are examined with high powers, cloudy patches are seen diffused through the substance, which under still higher powers resolve themselves into innumerable particles having very definite outlines, some transparent and some opaque. At the same time fresh cloudy patches are brought into view, requiring still higher powers for their resolution; and so the process may go on, as it does in examining the nebulæ with the telescope. The minute particles thus brought into view are called microliths or crystallites. Sometimes, instead of being indiscriminately diffused, they are collected in groups of very definite form, resembling the frost-work on

window-panes. In other cases they unite in radial groups about certain centers, and thus build up globular masses to which the name of "spherulites" has been given.

In Figure 1 No. 1 represents a glass through which microliths or crystallites of different dimensions and character are diffused. In

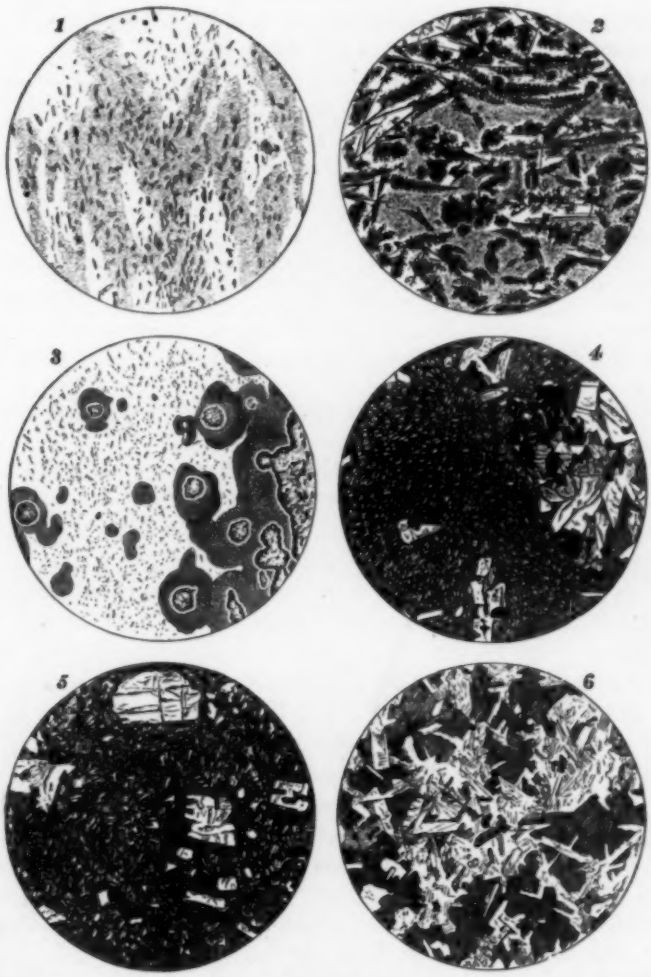


FIG. 1.—SECTIONS OF IGNEOUS ROCKS, ILLUSTRATING THE PASSAGE FROM THE GLASSY TO THE CRYSTALLINE STRUCTURE. 1. Vitreous rock. 2. Semi-vitreous rock. 3. Vitreous rock with spherulites. 4. Rock with cryptocrystalline base. 5. Rock with microcrystalline base. 6. Rock of granitic structure built up entirely of crystals.

Nos. 2 and 3 the crystallites have united to form regular groups. No. 4 represents a glassy ground-mass containing microliths (a cryptocrystalline base), through which distinct crystals are distributed, and is typical of the features presented by most lavas. Nos. 5 and 6 illus-

trate the characters presented by lavas which have consolidated at considerable depths below the surface.

The microliths have been proved to be the minute elements from which common crystals are built up; and cases occur in which a group of them may be seen gradually assuming the outward form and internal structure of a crystal, and in other cases crystals may be found which are undergoing a disintegrating action, and are then seen to be made up of minute elements similar to the microliths.

The same materials which go to form a lava may assume a glassy condition, or that of a rock built up entirely of crystals. Geologists have given distinct names to the glassy and crystalline forms of lavas, which correspond with the five great classes into which lavas have been divided as follows:

Crystalline forms.	Lavas.	Glassy forms.
Granite	Rhyolite	Obsidian.
Syenite	Trachyte	
Dyorite	Andesite	
Miascite	Phonolite	
Gabbro	Basalt	Tachylyte.

The obsidians do not exhibit enough differences to demand a distinction.

When the large crystals imbedded in granitic rocks and in some lavas are examined with the microscope, they are often found to contain numerous minute cavities, each of which resembles a small spirit-level, having a quantity of liquid and a bubble of gas within it.

In No. 1 of Figure 2 a group of such cavities is represented, one of which is full of liquid, while two others are quite empty; the remaining cavities all contain a liquid with a moving bubble of gas. In No. 2 two larger cavities are shown, containing a liquid and a bubble of gas. In Nos. 3, 4, and 5 the liquid in the cavities contains, besides the bubbles, several minute crystals; and in No. 6 we have a cavity containing two liquids and a bubble.

In the largest of such cavities the bubble may be observed to change its place when the position of the cavity is altered, so as always to lie at the upper side, just as in a spirit-level; while in the smallest cavities the bubbles appear to be endowed with a power of spontaneous movement, and are seen continually oscillating from side to side and from end to end of the hollow, as in Figure 3, where the dark line shows the path pursued by the bubble. These cavities are exceedingly minute, and so numerous that there must be millions of them in some crystals; indeed, in certain cases, as we increase the magnifying power of the microscope, new and smaller ones continually become visible; and it has been estimated that in some instances the number of them amounts to from one thousand million to ten thousand million in a cubic inch of space. In many cases the included liquid is water containing saline matters in solution,

and often so saturated that free crystals of the salt appear floating in it; in other cases it is some hydrocarbon; and sometimes it is liquefied carbonic acid. The presence of these liquids under such circumstances shows that the crystals have been formed under an enormous pressure.

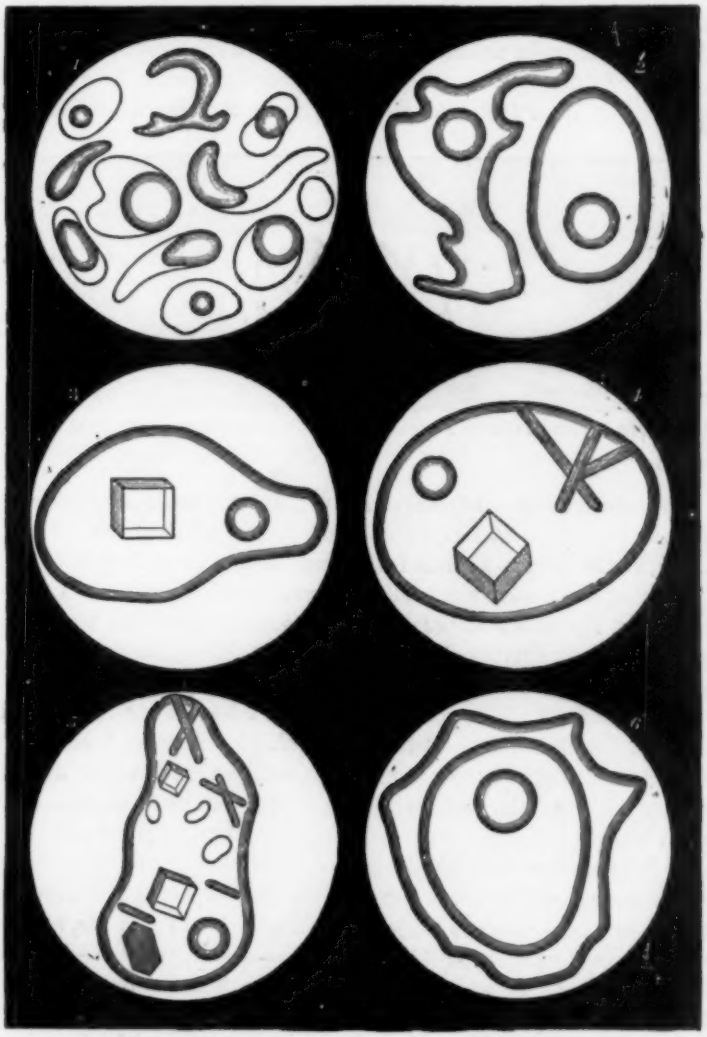


FIG. 2.—MINUTE CAVITIES, CONTAINING LIQUIDS IN THE CRYSTALS OF ROCKS.

The surface of fluid and semi-fluid lavas is covered with vast quantities of froth or foam which has been generated by the action of the escaping steam. If the lava consists of a mass of crystals floating in a liquid magma, this froth cools into the rough, cindery-looking mate-

rial which is called scoria. If the lava is glassy it becomes pumice, a mass of minute glass bubbles drawn out in one direction by the movement of the mass while it was still in a plastic state. Fragments of scoria and pumice are often thrown by a violent escape of steam to a height of hundreds or thousands of feet into the atmosphere. While going up and coming down, they encounter each other and wear each other away by their frequent rubbing, with a noise which is one of

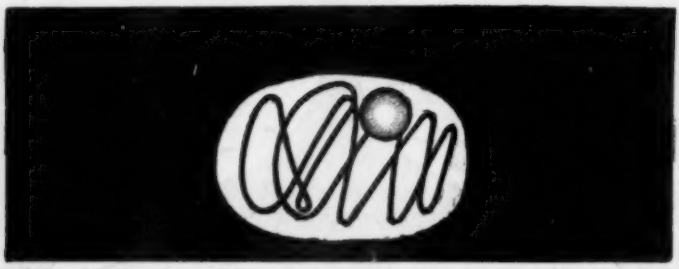


FIG. 3.—MINUTE LIQUID-CAVITY IN A CRYSTAL, WITH A MOVING BUBBLE. (The path of the bubble is indicated by the dark line.)

the most noteworthy accompaniments of volcanic eruptions. Mr. Poulett Scrope, who watched the Vesuvian eruption of 1822 for nearly a month, remarks that at first fragments of enormous size were thrown out, but that they were gradually reduced by constant re-ejections, till at last only the most impalpable dust issued from the vent—a dust which was so excessively finely divided that it went everywhere, even into the most closely fastened boxes. Mr. Whymper estimates that no less than two million tons of dust must have been ejected during a single slight outburst of Cotopaxi which he witnessed; and Professor Bonney calculates from actual examination that it would take from four to twenty-five thousand particles of this same dust to make up a grain in weight!

The temperature and consistency of lava-streams vary greatly, and the variations give rise to differences in the appearance of the cooled mass. The surface of the stream cools rapidly in the air, so that it appears dull-red at night and black by day—like a great mass of rough cinders—while all is of a white heat beneath, and may be so seen at night shining through the rough, cindery masses. Some streams are very liquid, resembling rivers and filling every channel in their course; while others, cooler and stiffer, might be more fitly compared to glaciers, creeping along so slowly that the fact of their movement can be established only by the most careful observation. The stiff lavas leave a crust wrinkled and folded like coils of rope, and are then frequently called "ropy lavas." The very liquid, fast-flowing lavas leave a surface covered with rough, cindery masses presenting jagged projections. Admirable examples of the ropy lava are afforded by the Vesuvian lava-stream of 1868 (Fig. 4), and by the lava-cascade of the Island of

Bourbon, where the stream, flowing over a precipice, has left heavy pendent masses resembling the drippings of a guttering candle. Another illustration of the forms produced by very viscid lavas is afforded by the so-called "mamelons" of the island of Bourbon. The flow of rapid

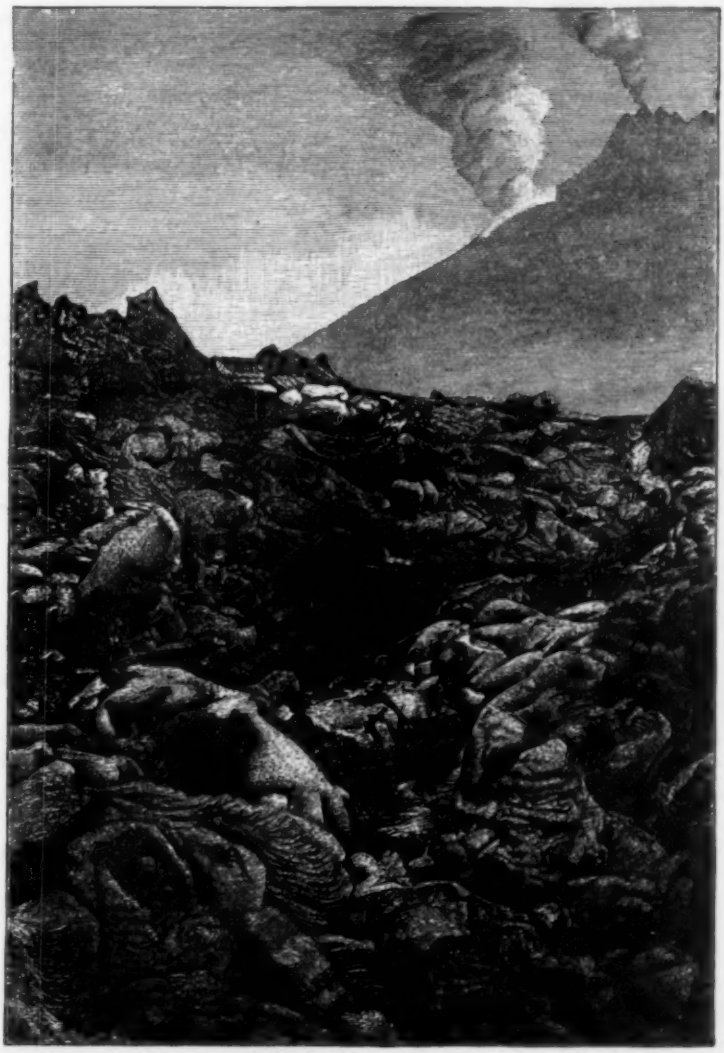


FIG. 4.—VESUVIAN LAVA-STREAM OF 1858, EXHIBITING THE PECULIAR "ROPY" SURFACES OF SLOWLY-MOVING CURRENTS. (From a Photograph.)

currents is generally accompanied with the disengagement of vast quantities of steam, and this, doubtless, has much to do with the formation of the cindery projections which characterize the cooled surfaces of such streams. Little parasitic volcanoes are often formed on the top of the

lava by the action of the escaping steam. Some such miniature volcanoes, formed on Vesuvius in 1872, were so small that they were carried away on boards to be employed as illustrations in the lecture-rooms

FIG. 5.—CONCENTRIC FOLDS ON MASS OF COOLED LAVA.

of the University of Naples. When very viscous lavas are forced through fissures, they arrange themselves in concentric masses, like that represented in the illustration (Fig. 5), which is from New Zea-

FIG. 6.—MASS OF COOLED LAVA FORMED OVER A SPIRACLE ON THE SLOPES OF HAWAII.

land. More liquid masses give rise to variously shaped structures, the bottle-shaped heaps of the "petrified fountains" (Fig. 6), or forms illustrated by the groups (Fig. 7) of small cones from Vesuvius. The con-

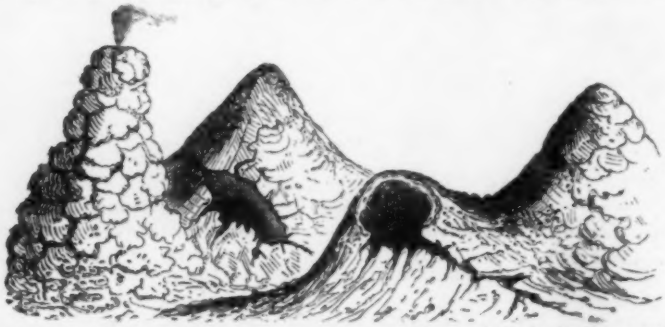


FIG. 7.—GROUP OF SMALL CONES THROWN UP ON THE VESUVIAN LAVA-CURRENT OF 1855.

traction of lava in cooling tends to produce fissures through the mass, breaking it up into prisms. Hence we have the columnar structure

of basalt. A similar structure is exhibited in all kinds of lavas, and in other rock-masses which have been heated by contact with igneous rocks and gradually cooled. Columns of a dissimilar character are produced by the unequal cooling of different parts of the stream, so that, if the stream be thick, the lower parts will form stout, vertical columns of great regularity; while the upper part, cooling less regularly, will produce smaller and less regular columns (Fig. 8). Fingal's

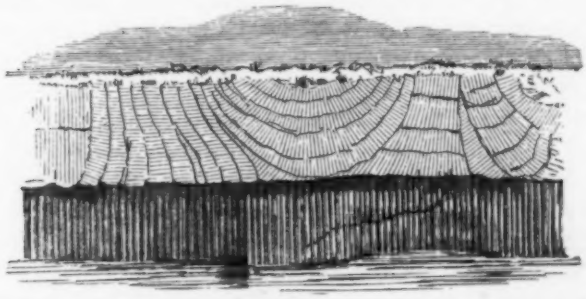


FIG. 8.—SECTION OF A LAVA-STREAM EXPOSED ON THE SIDE OF THE RIVER ARDÈCHE, IN THE SOUTHWEST OF FRANCE.

Cave, in the Island of Staffa, has been formed in the midst of a lava-stream which has been cooled in this manner. The thick, vertical columns, which rise from beneath the level of the sea, are divided by joints and have been broken away by the action of the sea, and a great cavern has been produced, the sides of which are formed by vertical columns, while the roof is made up of smaller and interlacing ones; and the whole structure bears some resemblance to a Gothic cathedral. The columns formed in cooling vary in size from those of the Shiant Islands, near Skye, which are eight or ten feet in diameter and five hundred feet long, to the minute columns, an inch or two in length and hardly thicker than a needle, of the volcanic glasses. The larger columns are formed in slowly cooling masses. The quantity of matter that is ejected from volcanoes in the form of lava is truly enormous. Lava-streams have been described which have flowed for a distance of from fifty to a hundred miles from their source, and which have had a breadth varying from ten to twenty miles; some are five hundred feet thick, or even thicker. A mass estimated to be equal in bulk to Mont Blanc flowed out in a single eruption of Reykjanes in Iceland, in 1783. In many parts of the earth's surface, among which are tracts in our Rocky Mountain regions, successive lava-sheets have been piled upon one another to the height of several thousand feet, and cover areas of many hundred or even thousand square miles. The marks of the effects of the passage of the hot volcanic matters, with the powerful chemical agents with which they are charged, are left upon the adjoining rocks, where, for a considerable distance from the vent, limestones are converted into statuary marble, sandstones into

quartzite, clays become hardened and lustrous, and coals assume a form like coke and graphite. Crystalline minerals and gems are formed, the rarest ones under a combination of powerful forces of heat and pressure which has been imitated by man only in the feeblest degree, most notably in the production of minute artificial diamonds by Mr. Hannay. The steam-jets which issue from volcanic fissures carry up fragments of rock torn from the sides of the vent, in the cavities of which beautiful crystallized products are often found. The various metallic minerals have nearly all been brought from away down in the earth's crust and deposited upon the sides of rock-fissures, the same volcanic forces opening the cracks through the solid rock, and then bringing up the metallic compounds and causing them to crystallize on the sides of the fissures. The cavities of the igneous rocks, when filled with water, constitute laboratories in which real chemical reactions take place—where the materials of the lava are gradually dissolved and recrystallized in new combinations, and the agates, the onyxes, the rock-crystals, the Iceland spars, and the class of zeolites have been formed. "No one can visit a large collection of crystalline minerals without being struck with the great number of beautiful substances which have thus been formed as secondary products from volcanic materials."

Hot springs, geysers, and carbonic-acid springs, which are also volcanic in their origin, afford another variety of curious products. Hot springs often contain in solution large quantities of silica, which has been taken up at the moment of its separation from the alkalies or alkaline earths with which it has been combined, and which is deposited when the water, having reached the surface, is relieved from pressure and cools down. Thus are formed the basins of the geysers of Iceland,

FIG. 9.—SINTER-CONES, SURROUNDING THE ORIFICES OF GEYSERS. 1. Basin of the Great Geyser, Iceland. 2. Hot-spring cone. 3. Old Faithful. 4. The Giant Geyser. 5. Liberty-Cap. (2, 3, 4, and 5 are in the Yellowstone Park district of the Rocky Mountains.)

and the curious structures with fanciful names which distinguish the geysers of the Yellowstone. The outlines of some of these structures are given in the figure (Fig. 9). The deposited silica is known to geologists as "sinter." Carbonic-acid water, in a similar manner,

losing its acid on exposure to the air, leaves a deposit known as "travertine," sometimes in great masses. In the Auvergne, the travertine exists in large rocks which take the form of natural aqueducts and bridges; in Carlsbad it has filled the whole bottom of the valley, and lies under the foundations of the town; and in Rome it has furnished the stone for St. Peter's and all the principal buildings. When springs charged with silica or carbonate of lime appear upon the slope of a hill composed of loose volcanic materials, they give rise to the remarkable structures known as sinter- and travertine-terraces. The water flowing downward from the vent forms a hard deposit upon the lower slope of the hill, while the continual deposition of solid materials within the vent tends to choke it up. As a new vent can not be forced by the waters through the hard rock formed below, it is opened a little higher up (Fig. 10). Thus the site of the spring is gradually

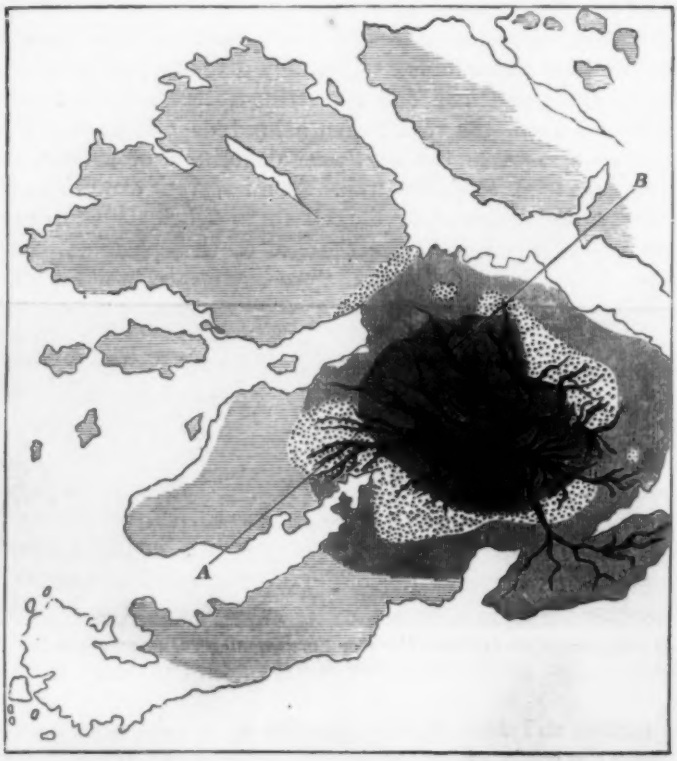
FIG. 10.—DIAGRAM ILLUSTRATING THE MODE OF FORMATION OF TRAVERTINE- AND SINTER-TERRACES ON THE SIDES OF A HILL OF TUFF.

shifted farther and farther back into the hills. As deposition takes place along the surfaces over which this water flows, terraces are built up inclosing basins. Of structures of this kind we have remarkable examples in the sinter-terraces of Rotomahana in New Zealand, and the travertine-terraces of Gardiner's River in the Yellowstone Park.

We sometimes find examples of volcanoes which by the action of denuding forces have had their very foundations exposed to view. Such examples occur in the Western Islands of Scotland, where we are able to trace the ground-plan of the volcanic pile, and study the materials which have consolidated deep beneath the surface in the very heart of the mountain. An admirable specimen of them is given by the "dissected volcano" forming the Island of Mull, which was probably originally nearly thirty miles in diameter at its base, and ten or twelve thousand feet high, but is now reduced to a group of hills few of which are more than three thousand feet high. Here, as shown in the figure representing the ground-plan (Figs. 11 and 12), great masses of granite, syenite, and diorite—the crystalline representa-

tives of the first extruded lavas—are penetrated by intrusions of gabbro, the granitic form of the later ejected lavas. From these great intrusive masses of highly crystalline rocks proceed in every direc-

FIG. 11.—PLAN OF THE DISSECTED VOLCANO OF MULL, IN THE INNER HEBRIDES.



A
B
a Rocks, on which the volcano has been built up.
b Great intrusive masses of acid and intermediate rocks.
c Lava-currents of basalt which have flowed from d.
d Intrusive masses of gabbros and dolerite.
e Lava-currents which have flowed from b.
f Volcanic tuffs and agglomerates.

FIG. 12.—SECTION OF THE VOLCANO ALONG THE LINE *A B*.

tion spurs or dikes, which are evidently the radiating fissures formed during the outwelling of igneous materials from below, injected by fluid substances. Besides the vertical or oblique dikes we also find horizontal sheets, which, passing from the central masses, have pene-

trated between the surrounding strata, often to enormous distances. The hard crystalline materials and dikes remain now as mountains; the remnants of lava-streams stand as isolated plateaus; while the softer materials have been carried away. The matters ejected from volcanoes are often carried by winds or currents to very great distances. Pumice floats out upon the ocean, and has been found so thick near the Lipari Islands that a boat could hardly make progress through it, and so abundant near the Solomon Islands that it took ships three days to force their way through the floating masses. Volcanic dust has been blown all over the ocean and across it, and has been found by deep-sea soundings to cover the bottom of the deepest parts and those farthest from the land.

The results of volcanic action, whether viewed singly or collectively, appear immense, and seem to indicate that the earth is or has been the prey to tremendous and terrible forces. Yet the action passes, and probably always has passed, without inflicting any permanent disturbance upon the condition of the earth's surface over more than the most limited areas. Clear proofs exist that the volcanoes of the Hebrides, of the Auvergne, and of Hungary, were clothed in Miocene times with luxuriant forests. The Island of Java, near the heart of the present most active volcanic center on the globe, is at the same time one of the richest and most fertile spots in respect to vegetable and animal life. The slopes of Vesuvius afford the best field for vineyards, and are in constant demand for that purpose, notwithstanding the danger of spasmodic outbreaks, for the eruptions of the volcano are short and its periods of repose are long. Volcanic action is only one of the ordinary forces of nature, probably quite as beneficial as destructive in the long run.

THE CHEMISTRY OF COFFEE AND TEA.

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THE vegetation on the southern slopes of the eastern Himalayas, three or four thousand feet above the sea, though by no means luxuriant, is said to be very agreeable and of much interest to the botanist. Among the plants native to these slopes, planted in the course of nature during the preparation of the earth for man, and left wild with the elephant and the leopard, is a shrub growing from twenty to thirty feet high, and well worthy to be selected for pleasant foliage and fine flowers. The lanceolate leaves are from two to six inches long, and the flowers are large and white, very fragrant, in clusters of two or three in the axils of the leaves. This is the tea-plant, of the genus *Thea*, very nearly allied to the genus *Camellia*, of which the

Japonica and other species from China and Japan are favorite cultivations of the greenhouse in Europe and this country. Nowhere in the world but on the borders of the Himalayas and in the wild regions of Assam is the tea-plant found growing uncultivated, but it was not discovered in this its natural habitation until the present century. As a cultivated plant, the Chinese have certainly had it since the fourth century, and they claim it to be indigenous to their own soil—just as confidently as they claim the parentage of numerous valuable articles. China has given tea to the world, and has furnished a favorable home to the plant, which is nevertheless quite as well suited in its native land, farther east. When it became known in England that the tea-plant grew native in the highlands of the Himalayas, English companies engaged extensively in the cultivation of tea in that region, and finally, after the correction of notable failures in methods of culture and of cure, it appears that the finest teas of Asia are those of these mountain-plains and the choicest plants are of variety *Assamica*, lately propagated from the wild shrub of the mountains.

A child would ask the question, What is there so very good in the tea-plant or in its dry leaf? And a philosopher may well ask, What is there about it, that this article has had a commercial history since the early middle ages, and men toil to till it, and with infinite detail to pick it and dry it and roll it, and spread and stir and roast and toss it, and then carry it over the globe in quantities to distribute for every household and amounting in sum-total to a quarter of a billion of pounds every year? In the first place, what does the tea-leaf contain —the fresh leaf from the wild bush of the mountains, never gathered for use, or the leaf picked on the tea-farms and carried dry to your tea-caddy—what kinds of compounds are in it, and can no other plant than this produce them?

To leave out a long story of progressive investigations, and to say nothing of the ways and means of analysis, the chief constituent to be named is the alkaloid *theine*. When separated from the other constituents of the tea-leaf, so as to be seen in its perfect purity, theine appears in snow-white, silky, filiform crystals, flexible and fragile, without odor, but having a mildly bitter taste. It dissolves readily in ten times its quantity of boiling water, and more slowly in a larger proportion of boiling water. It does not vaporize or decompose in the least at water-boiling heat; it melts at higher temperature and vaporizes slowly at about 360° Fahr., without decomposition. Chemically, it is a compound of the four organic elements, and is classified within the borders of the great group of alkaloids, but it differs distinctly from all other alkaloids (except its near relative, theobromine) in various chemical characteristics. It has, also, a much larger proportion of nitrogen than the other natural alkaloids. But it remains an important consideration that this crystalloid constituent of the tea-leaf is built on the chemical type of the alkaloids, a class of bodies which

nature forms in plants but not in food-plants—bodies that include narcotics, stimulants, hypnotics, delyriants, poisons, antidotes, tonics; some of them affecting the whole nervous system, one to excite and another to depress, and others influencing only parts of the nervous system, for special functions of the body. There is an alkaloid that gives steady impulse to spinal nerves, causing continuous contraction of one set of the muscles of the body; another that diminishes nervous effort upon all the muscles, and so impresses the brain as to produce sleep along with dreamy activity of the mind; another that, among other effects, so controls certain muscles as to open wider the pupil of the eye, and another that promotes digestion by arousing force in the nervous supply of secretory functions. Again, in the observation of the effect of an alkaloid it is found that, while a small portion stimulates the nervous system, a large portion acts as a sedative, so that a difference in quantity of the potion causes a difference in kind of its effects. By far the greater number of alkaloids do exert some sort of specific effect on the nervous system, but even to this generalization there are exceptions, and we could really infer nothing from analogy as to the effect which theine should have on the system.

The administration of theine in small portions, to animals or to man, quickens the circulation and effects some degree of mental exhilaration and wakefulness. In final result, the excretion of carbonic-acid gas is diminished, and the flow of blood through the capillaries is retarded. Larger portions prove poisonous, causing painful restlessness, rigidity of the muscles, and general exhaustion. Not more than three or four grains at once can be properly taken for medicinal or experimental purposes. As to the effects of the habitual use of small portions of theine, the tea-drinking peoples of the world ought to be competent witnesses, and their testimony, *pro* or *con*, may be brought by any advocate before the judgment of the world.

But we have to ask whether the alkaloid theine is found elsewhere in the vegetable kingdom. The coffee-tree (*Coffea Arabica*, *Rubiaceæ*) appears to have been planted by Nature in the heart of tropical Africa. At present it grows wild in Liberia, and is cultivated in most regions of the tropical world. It is twenty to thirty feet high, though, like the tea-plant, in the course of culture it is cut down to the height of five or six feet. It has the general appearance of a cherry-tree. It is an evergreen, with leaves four or five inches long and one and a half or two inches wide, and bearing clusters of white and richly fragrant flowers, the fruit being dark-red when ripe, and each holding two seeds, the coffee-berries of commerce.

In chemical analysis coffee yields an alkaloid, at first named *caffeine*, but long since determined to be identical with the alkaloid of the tea-plant, so that while the terms *theine* and *caffeine* are both in use, chemists recognize them as synonyms. Theine is found not only in the seed—the "berry" of the coffee-plant—but even more

abundantly in the leaf, though the latter, of less agreeable flavor, has been little used, and is not in commerce. The use of the coffee-leaf is further discouraged by the fact that the plucking of the leaf is injurious to the crop of the berry.

The chemist also finds theine or caffeine in two South American plants, the maté and the guarana. The former, *yerba maté*, or "Paraguay tea" (*Ilex Paraguayensis*), is a small forest-tree, bearing fine white flowers, indigenous to Brazil and the Argentine Republic, where it has long been prepared for a beverage which is drunk throughout South America. The leaves and twigs are employed, sometimes with inclusion of the fruit. Brazil also furnishes guarana, an article known in medicinal commerce, and obtained from the seeds of *Paullinia sorbilis*, a climbing shrub. Its fruit is of the size of the grape, and has a single seed. The seeds are bruised into a pulp, molded into cylindrical cakes, and dried. So prepared, guarana is in habitual use in South America, infused as a beverage, and also taken solid as an adjunct to food.

One more plant has to be named as a source of theine—the tree of the cola-nut, of Western Africa (*Cola acuminata*). The tree, of which two varieties are found, one with broad and one with narrow leaves, has been cultivated somewhat in tropical countries. The nuts are of the size of a pigeon's-egg, of a brownish color, a fragrant odor, and aromatic, bitter taste. The natives prize them very highly, using them in the solid state as a condiment with food, and to sustain strength during continued exertion when the supply of food is deficient. The cola-nut is rich in theine, as first shown by the analysis of Professor Attfield, at London, 1864.

So far, then, only five plants on the globe have been found to contain the alkaloid theine or caffeine, but the chemist finds an alkaloid very closely allied to this one, though of distinct individuality, namely, theobromine. This interesting chemical compound is homologous with the alkaloid of tea and coffee, differing in the molecule by one atom of carbon and two of hydrogen, theine having the structure $C_8H_{10}N_4O_2$, and theobromine $C_7H_8N_4O_2$. The relation is the same as that between any two contiguous members of the methylic alcohol series. Theine is constituted as methyl-theobromine, $C_7H_7(CH_3)N_4O_2$, and the chemist finds it an easy task to change theobromine into theine. Now, theobromine can be artificially produced from xanthine ($C_5H_4N_4O_2$); indeed, theobromine is dimethyl-xanthine, and theine is trimethyl-xanthine. In other words, xanthine may be presented as a chemical ancestor of the active principle of tea and coffee, and so it becomes of interest to inquire into the origin of xanthine, so called. In reply, it must be said that xanthine is not found in plants, but it is found in chemical laboratories; it is not a myth, and it can be made from a good many things that are abundant on the face of the earth. It can be made from uric acid, and

(1) Shown in 1884 not to be true, by E. Fischer

it can be made (simply by action of nitrous acid) from guanine, which is abundant enough in guano. Guanine is found here and there in animal excrementitious material, is produced by spiders, and occurs in the pancreatic gland of the horse, and in organs of the salmon. The extensive group of bodies related to xanthine and theine have been found a very rich field of chemical research. Theine itself is a body of a very simply distinctive chemical structure, from which numerous derivatives are readily constructed. Hitherto, however, the chemical synthesis of theine from inorganic elements fails by lack of some short link whereby to form uric acid from any one of its own derivatives, nearly all which can be artificially formed. But the change of guanine into theine is easily accomplished. It is perfectly practicable to bring guano material to the laboratory, and send away the same atomic elements transformed into the snow-white, silky crystals of theine. Given only a sufficient demand for the pure stimulant principle of tea and coffee, and a market value high enough above the cost of its vegetable sources, and it might then safely be predicted that not many months would elapse before companies with thousands of capital stock would engage successfully in the chemical manufacture of theine from guano. Then, very likely, rival companies would establish the claim to manufacture a still purer article from certain of the waste substances of the world—articles more accessible than guano.

But it must not be forgotten that theobromine, just mentioned as an intermediate body in the chemical transmutation of guanine into theine, is itself an alkaloid of well-known vegetable origin. It has been found in only one plant (the *Theobroma cacao*), a beautiful evergreen tree of Mexican nativity, extensively cultivated in South America, growing twenty to thirty feet high, bearing small flowers in clusters on the large branches, and yielding fruit in a purple-yellow pod, seven or eight inches long, each holding twenty to forty seeds—the "cocoa-beans" of commerce. From these are prepared all the forms of chocolate, "cocoa," and "soluble cocoa," now in use over the world as a beverage, a competitor for the favor accorded to the more nearly equal claims of coffee and tea. At the discovery of Mexico and Peru, the Spaniards found chocolate from time beyond record an habitual beverage, and the chocolate-tree in extensive cultivation, in both countries.

The chemist has yet to find, if he can, a plant on the globe containing the alkaloid theine, or its chemical associate, theobromine, that has not been, by some of the races of men in some of the ages of the world, brought into use as a refreshing beverage, or adjunct to food, prized for adding cheerfulness to nourishment, and giving solace to fatigue. However the peoples of the world—while wholly unconscious of the identities of chemical science—have been guided in their search over forest and field for a herb to infuse, in a beverage that should cheer but not inebriate, it is certain that no hint

of common qualities is to be gained from the external aspect of the plants so brought into use. Between the leaf of the tea-plant and the long pod of the cacao-tree there is no visual resemblance to indicate a common constituent, or to suggest a parallel use. As unlike as their general appearance, even more diverse are the botanical characteristics of the caffeine-containing plants, representing, as they do, diverse families in the vegetable kingdom.

In the modes of *preparation for use*, the sources of caffeine present some coincidences, with many diversities. The *coffee-berry*, except in some Eastern countries, is roasted, an operation to which its valued fragrance is almost wholly due. The roasting develops from inodorous constituents a very diffusible empyreumatic oil of very appetizing odor. In the more elaborate preparation of the *tea-leaf* a degree of roasting appears to be always necessary for development of agreeable flavor, while a certain extent of fermentation precedes the roasting in the manufacture of black teas. For black tea the leaves are withered a little, rolled to liberate the juice, then left in balls for just enough fermentation, then sun-dried, and subjected to a careful firing in a furnace. For green teas the fresh leaves are first withered in hot pans, then rolled to liberate the juices, and slightly roasted in the pans, now sweated in bags, and returned to the pans for a final slow roasting, with stirring for eight or nine hours, beginning at the temperature of 160° Fahr. and falling to 120° at the close. These operations are here given as now conducted by the planters in India, and as proposed for tea-culture in the Southern United States, and are considerably abridged from the time-established routine of minute detail in China. The teas of commerce contain a distinct essential oil, a constituent which does more than all others to obtain the esteem and fix the value of each grade of tea in the market. The question of the effect of the curing process upon the essential oil—to liberate or generate or modify or dissipate it—is an inquiry of no little interest and consequence, and deserves more chemical investigation than it has received. In the manufacture of all the forms of *chocolate*, the cacao-seeds, cleared of the shell-coat, are roasted to begin with. Without further treatment they constitute the "cacao-nibs." When ground, pressed to remove a part of the oil, made with sugar into a paste, flavored with vanilla, spices, etc., and cast in molds, we have "chocolate" proper. When left in the pulverulent form, or molded in porous and friable cakes, the article is presented as cacao or "cocoa," or "soluble cocoa"—the proportion of oil being diminished either by its removal under pressure, or by adding some form of starch or farina. "Flake cocoa" is made by crushing the roasted seed, shell and all. In the preparation of the South American *maté*, the leaves and twigs are subjected to a "curing" process, and roasted under a covering of earth to develop an aromatic principle which gives flavor to the beverage. The *guarana*, also, is dried or lightly roasted, though acquir-

ing only slight fragrance. The African *cola-nut* is strongly aromatic as taken from the tree, and this seems to be the only one of the six chosen foods furnishing theine or theobromine that is not subjected to dry heat in its preparation.

Tracing, so far in our study, the common constituent of coffee and tea, in its occurrence in various vegetable products which have been appropriated, after similar methods of treatment, to the uses of adjunct food, it is full time to inquire what else is to be found in the tea-leaf, the coffee-berry, and the chocolate-nib, besides a certain stimulant alkaloid. With entire justice to the remaining components they may be here classified in three groups—nutritious substances, astringents, and aromatics.

Tea yields from thirty to fifty per cent of its substance to solution by prolonged boiling in water; but, as the beverage is properly prepared, probably not over twenty to twenty-five per cent of the solids are dissolved. This soluble portion includes dextrine, glucose, gum, and potassium salts, besides tannin and the alkaloid. The nutrient portion of tea is comparatively small. In coffee we have ten to thirteen per cent of fixed oil, and about the same proportion of legumine, with gums and extractive matters, and two per cent of soluble potassium salts. The roasting reduces the glucose from six or seven to one or two per cent, liberates the oily matter, and so modifies the legumine as to render it measurably soluble. The beverage seldom contains over ten or twelve per cent of the roasted berry in absolute solution, so as to be retained in the liquid when perfectly clear, but some of the finer powder is likely to remain in suspension, and the oil is held with the liquid, while hot, to a still greater extent. In quantity, the food-constituents of roasted coffee are generous enough, but in digestibility it is more than probable that they are deficient. As to the cacao-seed, its oil, constituting half its weight, is a substance well known in its separated state as cacao-butter, and is an agreeable and very wholesome form of oleaginous food. In quantity it ought not to be unduly diminished, either by removal with the press or by addition of farina, and it should constitute as much as twenty-five per cent of all of the cacao preparations. Besides the oil, a good portion of starch and about eighteen per cent of albuminoids are found in cacao-seeds, and all these are to a large extent obtained in chocolate beverages. The butter of these creamy liquids is less likely to cause disturbance of digestion than the roasted albuminoids they contain.

The astringents of tea and coffee are tannins, properly classified along with the numerous varieties of tannic acid, the astringent principles of plants. In tea the proportion is large, ranging, according to the lowest statements, from nine to twelve per cent, and placed by some authorities as high as thirty and forty per cent. Dragendorff reports green teas to bear a higher percentage of tannic acid than black, and this difference may be due to a decomposition of tannin

during the fermentation in the manufacture of black teas. But it is important to know that only a small part of this tannin is extracted from the leaf in the suitable preparation of the beverage. Some experiments with tea as it is prepared for the table gave, for a five fluid-ounce cup of the liquid, in ten instances an average content of a trifle over one grain of tannin. Other experiments with tea after five minutes' steeping gave in twelve instances an average of tannin equal to only $\frac{8}{100}$ per cent of the dry leaf; while the same teas, on thirty minutes' gentle steeping, yielded tannin amounting to an average of 2½ per cent of the dry leaf. In another case, by thirty minutes' active boiling, so much tannin as 11½ per cent of the tea-leaf was obtained in solution. Black teas are necessarily steeped longer than green, as they yield all their soluble matters more slowly. In coffee the proportion of tannin is not over one third, perhaps on an average not over one fourth or one fifth, of that in tea. The cacao-nib and its preparations are free from tannin. Guarana is heavily charged with a specific variety of tannic acid, and the maté is even more astringent than the tea-leaf.

The fragrant principle of tea, the essential oil, already referred to, has not been separated in notable quantities, but it is recognized as a diffusible stimulant, transient and harmless in its effect on the system, and certainly attracting no little favor to the tea-cup. The diffusible flavorous substance of coffee is a product of its roasting, and the same is true of the proper fragrance of cacao, to which other odors are often added. These vaporous bodies are so easily dissipated by a prolonged steeping, and especially by an active boiling, that brief infusions of tea and of coffee are likely always to be preferred.

In the quantity of the alkaloid, theine or caffeine, the tea-leaf is over twice as rich as the coffee-berry. The medium proportion is that of 2 to 2½ per cent in tea, a little under 1 per cent in coffee, and about 1½ per cent (theobromine) in the cacao-nib—while the guarana preparation has 5 per cent, and the maté 1½ per cent. Attfield found 2 per cent of alkaloid in the cola-nut. From a pound of tea, then, there can be obtained at least 140 grains, or over a quarter of an ounce, of the crystallized alkaloid, about enough to balance a silver quarter-dollar and a dime. The theine in a pound of tea is twenty-five or thirty times as much as could be taken at once without notable disturbance of the nervous system. A pound of coffee contains twelve or fifteen times as much theine as one ought to take at once.

The greater portion of the alkaloid enters into solution in making the common hot infusions of coffee and tea. Tea yields its alkaloid to hot water upon even brief application; coffee, especially when but lightly roasted, requires longer steeping for the extraction of the theine. It may be said, then, of long steeping of coffee and tea, that it is not required in obtaining the chief portion of the stimulant principle; that it only serves in the case of coffee to increase somewhat

the nutrient matters; that, unless in tightly closed vessels, it wastes the fragrance, the qualities held in choicest esteem and highest value; and that, when used with teas, it renders the beverage so strongly astringent as to be both disagreeable and unwholesome.

The opinion is general, though not universal, that coffee is a stronger stimulant than tea, comparing them as American beverages. On this question, the analyst can only aver that a given weight of tea-leaf yields about three times as much of the common stimulant principle as the same weight of roasted coffee. How many cups of tea may be made from a pound of the dry leaf, or how few cups of coffee are made from a pound of the browned berry; and how long either quantity, dispensed under regulations both prudent and generous, will continue to supply a flowing cup in daily service of an individual—these questions may be respectfully referred to authorities more competent than chemists. The proper judges can comprise none other than the gracious autocrats of the tea-table themselves; and when they shall have vouchsafed perfectly definite replies, regarding these desired numbers and quantities, then in a very short time some assurance can be given of the stimulating effects of coffee in comparison with tea.

But, pending all conclusion from chemical identity and parallel quantity of constituents, any sufferer from coffee may resort to tea, and any injury from either may be cited against the closest chain of reasoning which chemistry can present. Most people have a small stock of experimental science of their own, sufficient for personal theory, if not wholly in accord with personal practice. And now regarding the effects of coffee in comparison with tea, let it be remembered that sleeplessness during the hours of repose may come from irritation in the stomach as well as from stimulation in the brain. The rich, oily, and albuminoid matters of roasted coffee, and especially the empyreumatic oil to which its flavor is due, are liable to derange the digestion of many persons, while tea is seldom subject to this disadvantage, and its diffusive fragrant oil may be helpful to the action of the digestive powers. In countries where the people rarely have indigestion, it is not found that coffee prevents sleep more than tea, but this report is often made in America, where the digestion is not the best in the world. The astringent influence of tea, unless prepared with brief steeping, may produce ultimate injury, but seldom causes immediate disturbance. To the action of the stimulant alkaloid itself, of course some persons and some nations are more susceptible than others, but we may be sure that it is only from this action that increased mental activity and the wakefulness of nervous exhilaration are obtained, alike in the use of coffee and of tea. And it is doubtless far more from this action of the one alkaloid found in both beverages, than from any other constituents, that their habitual use becomes injurious to many persons.

The consumption of coffee and tea in the United States in one year

(1877) provides about 8½ pounds of coffee and 1⅓ pound of tea to each inhabitant. The importation of coffee, in Europe, is stated to furnish for each inhabitant, in France, 2 1/10 pounds; in Belgium, 13½ pounds; in Holland, 21 pounds; in Sweden, 6 pounds; in Norway, 9 pounds; in Austria, 2 pounds; in Russia, ⅛ pound; in Italy, 1 pound. In Great Britain, the consumption of coffee has been on a decrease for the last thirty years. The tea consumption in that country amounts to 2 pounds to each individual. The total amount of tea consumed on the globe would give about ¼ pound to each of its inhabitants.

The grades of coffee in the market come from different varieties of the tree, and from different countries where it is cultivated. The various kinds of tea result primarily from differences in the age of the leaf when gathered. The choicest teas are from the younger and more succulent leaves, the earliest leaf producing flowery pekoe, the next orange pekoe, then pekoe and souchong, and from the oldest leaves bohea proper. Differences of manufacture have already been noted for black and green teas. The processes of manufacture in China and India are necessarily modified to enable the tea to bear sea transportation without injury, and it must be accepted that the finest tea can only be obtained in tea-growing lands. When American enterprise shall have devised such means of preparation as may dispense with the present lavish use of hand-labor in Asia, then we may have tea ranking above tobacco in the products of the Southern United States.

The adulterations of tea comprise mineral matters, foreign leaves, and spent tea. The food-analysts of Great Britain have fixed the maximum limit of eight per cent of mineral matter, including three per cent to be soluble in water, and a minimum limit of thirty per cent aqueous extract. The color-facing of turmeric, prussian-blue, and gypsum, though not excluded as fraudulent, is characteristic of poorer qualities of green teas. The adulterations of coffee, sold in the ground condition, are multifarious, all sorts of roasted grains, nuts, and shells having been taken for this use, but the chiccory-root has been the most extensive admixture, and in Great Britain has been in actual demand by the consumer. Even the entire coffee-berry is sometimes counterfeited—a suggestion from the legendary wooden nutmegs of New England invention. But we may trust that the great body of tea and of unground coffee in commerce is nearly or quite innocent of adulteration. No positively hurtful impurities are apt to be found, but not the less all falsifications of these or other articles of food should be severely punished. It is clearly a misdemeanor to tamper with the food which any man may select by its distinctive name, in his own discretion, for his personal use.

Notwithstanding the adoption of theine-containing beverages by mankind at large, we can not hesitate to commend that robust habit which discards all dependence on adventitious food, even on so mild a stimulus as that of the tea-cup, and preserves through life the fresh

integrity of full nervous susceptibility. And probably there was never a time when there were so many persons as now who are disposed, by conviction and by a desire for a stalwart physical independence, to refuse to fix any habit that holds the nervous system.

But, taking the world and its discomforts as we find them, it must be granted that the thralldom of tea is comparative physical freedom, and we can gladly give voice to those who praise these comfortable beverages. "Near the fire," says De Quincey, "paint me a tea-table —place only two cups and saucers upon it—and beside them paint me an eternal tea-pot. . . . For tea," he says, "will always be the favorite beverage of the intellectual, and for my part I would have joined Dr. Johnson against any impious person who should presume to disparage it."

THE ANATOMY OF AN OLD ANECDOTE.

By WILLIAM W. BILLSON.

IT is a matter of common knowledge that Shakespeare's story of the bond for a pound of flesh is not of his own invention, but is merely a modern and dramatic version of a very old tale which, with slight but frequently significant variations in form, had already become the common property of many nations, East and West.

Even though these legendary antecedents of the drama had never been actually discovered, their existence could nevertheless with great confidence be affirmed; for in no other manner can we account for the singular and unconscious fidelity with which the anecdote illustrates legal conceptions highly characteristic of primitive ages, but alien to that in which Shakespeare lived.

The scientific value of a good story as a clew to the institutions, the intellectual and social life of the people among whom it originated, or in whose hands it has undergone modification, is now so well understood that to collect, anatomize, and interpret recently despised folk-lore, romances, anecdotes, and ballads, is a recognized function of modern scholarship.

The story of the bond is not only one of great inherent interest and scientific value—it is rendered doubly attractive as an object of study by the fact that a correct apprehension of its original meaning constitutes an excellent preparation if not an indispensable condition to a sound analysis of Shakespeare's play; to a discovery of the motives through which, as poet and playwright, he was led to select the story for the purposes of his art, and to a correct understanding of the many passages by which with admirable skill he sought to conceal or evade the annoying discrepancy between the ideas out of which, in the barren soil of a very remote antiquity, the story originally grew,

and those of the civilizations into which it was afterward transplanted. The inadequacy of the treatment which the anecdote has hitherto received is forcibly illustrated by an article in a late number of the "Nineteenth Century," in which Moncure D. Conway essays to unfold the principles lying at its root. Mr. Conway precipitately assumes that it is the product of theological conceptions, and, by confusing it with purely religious Hindoo legends, designed to inculcate the virtue of self-sacrifice, forecloses at the threshold of his inquiry all hope of conducting it to a successful issue.

He regards it as one of the earliest fables concerning the ever-conflicting principles of retaliation and forgiveness. To him Shylock is Indra tearing Vishnu's breast; Elohim demanding Isaac's death; the First Person exacting the Second Person's atoning blood. Antonio stands for the Christ, the forgiver, the sufferer. Antonio suffering for Bassanio is the just suffering for the unjust. The representative figures of the Venetian court-room are only transformations from the flying doves and pursuing hawks, bound victims and exacting deities of ancient mythology. Portia is that human heart which in every age, amid hard dogmatic systems and priestly intolerance, has steadily appealed against the whole vindictive system, whether Jewish or Christian. She is made to assume the ermine because, with his wonted felicity, Shakespeare perceived that the genius of this human sentiment, slipping through the technicalities of priest-made law, could be most fitly impersonated by a woman.

Now, while we can not concede the soundness of this interpretation, it is justly entitled to the praise which next to a positive indorsement will be most gratifying to one of Mr. Conway's philosophic turn of mind, that it is so palpably and almost comically unsound as to be perfectly harmless. It so obviously rests upon a systematic belittlement of the essential and exaggeration of the non-essential in the story, that, though interesting reading for all, there is little danger of its misleading any.

The widely diffused story of the bond originated in strictly legal conceptions. It embalms in an excellent state of preservation several interesting phases of early law.

Whether it is the record of an actual occurrence, it is alike immaterial and impossible to determine. Certain it is that both the facts and the law of the case are substantially historical. They precisely represent views concerning contract, criminal liability, and law reform, which, however absurd they may appear to us, have widely prevailed, and must be regarded as characteristic of certain early stages of intellectual development. In the bond itself, as it was regarded by the interested parties, we recognize the substance of the debtor's life-pledging contract which filled so large a place in the commercial economy of ancient societies. As a means of securing the payment of debt, the pledging one's life and the lives of the members of one's family, in the

history of many races, preceded in order of development the pledging of property—the right to legal process against the person likewise becoming established as a means of collection before process against property was known to the law. It was so with the Romans. The persons, the lives, of the debtor and his family were long considered by them as the creditor's normal security. It was fully four centuries from the foundation of the city before the Roman creditor was entitled to resort, without the debtor's consent, to any portion of the latter's property except such as had been delivered to the creditor in pledge. It would be interesting to inquire why remedies against the person thus preceded those against property; and, though too remote and obscure a problem for treatment here, we may hazard, in passing, the conjecture that the explanation is to be found in the generally communistic form of primitive property. When all property was vested in the village tribe or *gens*, the individual really had nothing he could call his own except himself and his family. The idea that the creditor's remedy was exclusively against the person, being thus engendered, would, through the sluggishness of the primitive intellect, continue to subsist long after its original cause had been removed by the institution of individual property. Again, the whole structure and theory of early society was such as to give credit and currency to measures which, while perhaps not legally charging the minor social and proprietary organisms with debts contracted by their constituent individuals, might yet be employed by the creditor of an individual to force the organization to aid its defaulting members. Such was doubtless one theory upon which the unconscionable power of the creditor over his debtor was upheld. It operated as a harsh and awkward leverage by which the creditor could reach the property, not only of the debtor, but of his sympathizing relatives and friends. However this may be, the power of the creditor was habitually pushed to such merciless extremity that indescribable hardships befell the debtor class in all the early civilizations. It is true that within historic times the creditor, in many instances, derived the authority for his atrocities, not from the stipulations of his contract, but from general provisions of law. The Roman law, under which a creditor could, at his option, put his defaulting debtor to death or sell him as a slave into a foreign land, and the several creditors of an insolvent could hew his body in pieces and divide it between them, is a fair example of the almost incredible inhumanity of the early law toward this unfortunate class.

The traits of character and the social conditions which led to the toleration of such laws, it would not be difficult to specify, for, though numerous, they are by no means obscure. But in this instance, as with all irrational customs, laws, or beliefs, the secret of their maintenance is a very simple matter compared with the mystery of their first cause. Assuredly it is hard to distinguish in the mere fact of indebtedness, in the simple relation of debtor and creditor, anything which could have

suggested the investment of the creditor by law with the unnatural power which we find him enjoying. That power, it is far more reasonable to suppose—indeed, the supposition affords the only plausible explanation of it—was originally claimed by the creditor as Shylock claimed his pound of flesh, only by virtue of the condition of his bond; only through the debtor's express concession of it at the time of incurring the debt. In the history of debtor and creditor, back of all life-forfeiting laws there must have been life-forfeiting contracts; the former being the outgrowth of the latter. That such stipulations, after becoming a customary clause in contracts, would have a tendency to crystallize into law, is aptly illustrated in the law of Scotland. It is shown by Lord Kaims that such has been precisely the history of imprisonment for debt in that country. Originally unknown, it was at first introduced by the debtor's agreement that, in case of default, process might issue against his person. The courts recognized the validity of such agreements, enforced them, and ultimately fell into the habit of allowing the remedy, without inquiring whether it was authorized by the contract or not.

Having thus noted the essentially historical character of the life-pledging contract, it is to be remarked that its legal recognition carries us back to the time when the right of contract was comparatively free from limitations as to its subject-matter. Under matured systems of jurisprudence a great variety of agreements are denied legal recognition, on the ground that their performance would involve a violation of law, or would be incompatible with good morals or public policy. But the catalogue of agreements thus condemned was originally very meager. Though it is probable that from the earliest times the law may have refused to enforce a few contracts of a grossly criminal character, it was only gradually that the broad principle was evolved that one can not legally obligate himself to the performance of an unlawful or immoral act, or an act inconsistent with public policy.

The story of the bond for a pound of flesh not only speaks to us, through the atrociousness of the contract, which was held valid, of the former feebleness and obscurity of that principle; it also affords an example of the curious indirection through which at first the principle usually ventured to assert itself. For, in all its forms, the story points to a society or a stage of development in which the law, while conceding the validity of the life-pledging contract, regarded it with great disfavor, and, in the interest of advanced views of morality and public policy, was seeking its overthrow.

Many versions, including Shakespeare's, represent the judge as affirming the validity of the bond, and the right of the creditor to take the stipulated flesh, and at the same time as declaring a forfeiture of all his estate for simply proposing so to do; a laughable incongruity, so utterly repugnant to existing legal views, and so strikingly representative of the methods of early law, as to constitute one of the

most curious features of our anecdote. For, even when ancient societies sought to discourage contracts made in contravention of law, morals, or public policy, it was their practice not to deny their validity but to rely for their suppression upon penalties denounced against parties who should enter into them. This indirect method of reform was eminently characteristic of such societies, and the evidences are abundant of its application to all branches of the law.

The conservatism of such communities was so controlling that, when, through changed social conditions, a modification of existing law became unavoidable, the tendency was, while adhering nominally to the old law, to inflict penalties upon or in some way obstruct those who attempted to assert rights under it; an expedient whereby the effects of amendment might be obtained without a confessed abandonment of ancient principles. The proverbial unchangeability of the laws of the Medes and Persians represents only in aggravated form the extreme aversion to change almost universal in early societies; and the effectual manner in which the unchangeable proclamation of King Ahasuerus for the extermination of the Jews was annulled by his subsequent decree, declaring it lawful for them to defend themselves, is not a bad example of the tortuous method of reform which we are now considering. Another example equally in point is afforded by the history of the doctrine of jurisdiction. In Europe certainly, and probably elsewhere, the jurisdiction of courts was originally voluntary. They tried causes only in the presence and with the consent of both of the litigating parties. It would have been regarded as an unwarrantable encroachment upon the liberty of the citizen for a court to entertain a controversy at the solicitation of the complainant only, and without the express consent of the defendant. This theory of jurisdiction disappeared in the different nations of Northern Europe at an early or late day in proportion to the strong or weak influence of the Roman law, and remained unshaken in England until within a century. At a very early day the principle was perceived to be inconsistent with the maintenance of social order. But, instead of renouncing it in favor of the rule since adopted, that the service of citation upon the defendant shall confer jurisdiction whether he consent or not, the old doctrine was rigidly maintained, and outlawry, forfeitures, and attachments were resorted to, to compel the defendant to signify his indispensable consent. If, in spite of these severe measures, the jurisdiction was still resisted, the court remained powerless to proceed.

The historical as well as the dramatic interest of our story culminates in the celebrated quibble through which the judge, after dispelling the forlorn hopes and realizing the worst fears of the debtor by sustaining the validity of the bond, suddenly puts an entirely new and happy face on the transaction. He says:

> " . . . Tarry a little; there is something else.
> This bond doth give thee here no jot of blood;

The words expressly are, *a pound of flesh;*
Then take thy bond; take thou thy pound of flesh;
But, in the cutting it, if thou dost shed
One drop of Christian *blood*, thy lands and goods
Are, by the laws of Venice, confiscate
Unto the state of Venice.
. . . . . .
Shed thou no drop of blood, nor cut thou less nor more,
But just a pound of flesh; if thou tak'st more
Or less than just a pound—be it but so much
As makes it light or heavy in the substance
Or the division of the twentieth part
Of one poor scruple—nay, if the scale do turn
But in the estimation of a hair—
Thou diest, and all thy goods are confiscate."

This play upon words is so transparently illogical, that while the righteousness of the end might in a romance he held to justify the absurdity of the means, the modern mind, and particularly the legally trained mind, intuitively shrinks from accepting it as the *bona fide* judgment of any court; a fact which, as we shall hereafter observe, is the key to the later modifications of the story. And yet nothing could be more suggestively true to nature and history than that a judge of the remote age from which this story is inherited, in struggling to assert against an old and harsh rule of law more recently developed sentiments of humanity, should seek the accomplishment of his purpose through a play upon words.

There is a popular superstition that such exercises are still the delight of lawyers; but the truth is that, in this age of highly developed rational faculty, a quibble has neither friends nor function, and is an object of universal contempt. There was a time when it was not so. A volume might be and indeed ought to be written upon the astounding and universal susceptibility to quibbles which characterized the ancient mind until Aristotle in Greece and Seneca in Rome. All literature, legal, philosophic, and religious, was sadly disfigured by them. The proneness of the really primitive mind to indulge in them is well known: it is not so generally appreciated how late it was in the history of intellectual development before the infirmity was outgrown. Even the imperial intellect of Plato, the life-long enemy of the professional sophist, staggered visibly and habitually under the influence of this sort of sophistical taint. Among the laws governing the concurrent evolutions of thought and language, there is one not yet fully definable, but unmistakably discernible in its effects, by which for ages the human mind was irresistibly addicted to the drawing of irrational verbal distinctions or analogies. Nor does the modern mind display in any respect a more marked contrast with the ancient than in its keenness to detect and swiftness to repudiate everything in the nature of a quibble. No one, for instance, would now admit that, conceding

Shylock's right to the pound of flesh, he should be held to incur death if, waiving a part, he took *less* than was called for by his bond. Yet that such a quibble was not always impossible, but is probably historical, must be inferred from the fact that the laws of the Twelve Tables, after authorizing the creditors of an insolvent to divide his body between them in the proportion of their respective claims, expressly provides that no creditor shall incur liability by taking, without bad faith, either more or *less* than his share. Whether this protection to the creditor taking less than his share was, as seems probable, enacted in settlement of an old and mooted question or only in anticipation of a new one, it is in either event highly significant as having been thought necessary in order to preclude just such a construction of the law as the judge in our story placed upon the bond.

Nor was the quibbling infirmity without its compensations. In the domain of law, at least, it had substantial functions, and paved the way to reforms otherwise unattainable. We have already had occasion to notice why ancient societies required methods of reformation not involving an avowed abandonment of established rules. To leave such rules nominally intact, and at the same time to indefinitely curtail or enlarge their operation by the withdrawal or addition of particular classes of cases through judicial construction, was a mode of legal amendment eminently adapted to the genius of such communities, and fruitful of many beneficent modifications of the law. It was a matter of minor consequence whether such modifications were effected by sound arguments or quibbles. In an age habituated to the amendment of law by legislation, nothing can be said in defense of the vicious practice of judicial quibbling. However faulty existing law may be, legislation is the appointed, effective, and only appropriate agent for its reformation. But, during the ages when men were as ignorant of the processes of legislation as they were implacably hostile to the theory of innovation upon which nearly all legislation proceeds, the only alternative was between an absolutely unprogressive condition of the law and an effort to bring it into harmony with the requirements of an ever-advancing society by a resort to such methods of amendment, however vicious or clumsy, as had then been efficiently evolved. The reform of law by judicial construction, however forced and illogical, being a much more familiar and agreeable process than amendment by legislation, the art of quibbling, of drawing distinctions where there was really no difference, and of detecting resemblance though there was no essential similitude, was employed with no inconsiderable effect in contracting or enlarging the operation of legal principles; and, exercised, as it usually was, in aid of the finer sentiments and more advanced conditions of a later age, against the crude customs of an earlier, was an important factor in legal development. The agencies by which early societies modified their law and which discharged imperfectly, indeed, yet almost exclusively, the func-

tions afterward discharged by equitable construction and still later by legislation, have been fitly grouped together under the common name of legal fictions. Sir Henry Maine, in adopting such a classification, explains that by a legal fiction he means any assumption which conceals or affects to conceal the fact that a rule of law has undergone alteration, its letter remaining unchanged, its operation being modified. Now, a judicial quibble was a kind of legal fiction—a product of the same conditions and charged with the same functions as legal fictions generally. That is to say, it was a thin disguise, under which, owing to the prevailing laxity and vagueness of current intellectual processes, reforms could be introduced without actively antagonizing the conservative propensity.

While amplifying the historical suggestions of our story, we must not ignore the interest attaching to the circumstance that the quibble employed by the judge was one which, though inspired by a desire to defeat the forfeiture, took effect not through an impeachment of the bond's validity, but in such a definition of the remedy upon it as was calculated to discourage its enforcement. It thus represents the very marked propensity of early societies to assail an obnoxious legal right indirectly through its remedy; impairing the latter either by regulations making a resort to it difficult or impossible, or by encumbering its exercise with stringent and technical limitations, the nonobservance of which would subject the party to heavy penalties.

It is in this tendency that we find the key to much that is otherwise unaccountably harsh, technical, or absurd in early judicial remedies and procedure. Whenever any recognized legal right came to be regarded as unconscionable or otherwise objectionable, rules adapted to hamper or imperil the complainant in the pursuit of his remedy were sure to spring up. Procedure, instead of being shaped as now with an eye single to the ascertainment and enforcement of the rights of litigants, was therefore frequently designed to render those rights nugatory; and, as the latter function was often more influential than the former in molding the procedure, so they were both at times overshadowed by such a regulation of remedies as would be most likely to frighten both parties out of court and into an amicable adjustment of their differences. We find ample illustration in the history of the law of distress. The right of a creditor to seize without legal process the goods of his debtor in satisfaction of his claim, which once so widely prevailed, may be said generally to have fallen a victim to the constantly increasing technicality of the procedure regulating its exercise. The value of the right was destroyed by the technicality which its harshness had induced; so that creditors were usually glad to abandon the right before it was taken from them. It was, as has been well said, a kind of two-edged sword. "You might bring your adversary to the ground by it, but you were extremely likely to injure yourself. For, unless the complainant who sought to distrain went through

all the acts and words required by law with the most rigorous accuracy, he, in his turn, besides failing in his object, incurred a variety of penalties which could be just as harshly exacted as his own original demand."

In like manner, and in deference to the same conservative propensities heretofore noted, an irrational rule of procedure was often adopted in order to preclude the exercise of unconscionable privileges by a defendant. Such, for example, was the origin of that disgraceful rule of English law which so long denied to persons accused of felony or treason the benefit of legal aid in making their defense. The English law of crimes and criminal procedure became at a very early stage in its history so excessively technical as to render it intolerably difficult to secure conviction in the face of a skillful defense. In obviation of this difficulty, the rule now is, that the proceeding shall be vitiated only by such inaccuracies as are substantially prejudicial to the accused. But the conservative tendency was formerly too strong to admit of this curtailment of the defendant's rights.

He must not be denied the right to immemorial objections, however irrational. But he could be hampered in the exercise of the right, and, as the most effective expedient for that purpose, he was denied the legal aid through which alone he could ascertain what his rights might be; and such was unquestionably the origin of the rule forbidding defense by attorney.

It is now reasonable to assume that the story of the bond was the product of the crude legal notions with which we have found it to be so replete. It is not within the scope of our inquiry to exhibit the bearings which this view of the story's origin may have upon its Shakespearean interpretation; but, that it casts strong light upon the latter subject, we have now occasion incidentally to point out.

The most noteworthy circumstance in the modern history of the story is its transformation into a comedy; no flavor of humor being discoverable in what were probably its earliest forms. It had already undergone this metamorphosis when it came to Shakespeare's hands. Italian predecessors of our poet, in adapting the story to their own civilization, recognized the absurdity of ascribing its obsolete legal notions to their own courts. To avoid so glaring an anachronism, they substituted, for the legitimate tribunal of the old story, an irresponsible mock court or make-believe judge by whom, without impropriety, the law of the story could be enunciated as a solemnly disguised jest. Henceforth the subject belonged of right to the comedians. Of all the legal conceptions embodied in the story, scarcely one could have emanated from a Venetian court; nor, indeed, when properly understood, do they purport so to do: they all without exception being transparently exhibited not as good law, but as the curious conceits of a playful and ingenious woman.

The graceful pleasantry which Shakespeare, following the Italians, has freely and deftly interwoven with the incidents of the original tale, avouches his realization of the radical change which had been wrought upon it by the unavoidable introduction of the mock court. He not only garnished it profusely with humorous passages, but, as Mr. Conway reminds us, produced it as a pronounced comedy in his own theatre. The fact that, notwithstanding this, the world has finally settled down upon a serious or pathetic interprefation of Shylock's character, and of the trial-scene, and exhibits a disposition, by repudiating the last scene of the play and by a variety of other expedients, to exorcise the comedy element, is certainly a high tribute as well to the irrepressible charm and dramatic quality of the old form of the story as to the overmastering power with which Shakespeare has told it. Whatever may be the merits of the reactionary or tragic interpretation, it has been largely facilitated by a vague assumption that Portia, though a usurper of the judicial office, might be, and, within the spirit of the play, ought to be regarded as a reasonably sound expositor of the Venetian law, and it is doubtful whether it would have been possible, had the public generally known as well as did Shakespeare and the Italians, that the mock court was improvised only because the time had long since passed when the law of the case could be plausibly credited with recognition in a legitimate tribunal. For, this being so, old Shylock, in the drama, through all the absorbing vicissitudes of the trial-scene, is as certainly the victim of a clever and frolicsome deception as was poor Christopher Sly, when, with manifold misgivings, he suffered himself to be persuaded that he was a lord, indeed, and not a tinker. It must, therefore, be admitted that the comic cast given to Shakespeare's Shylock by his early impersonators was not entirely inappropriate to so gullible an old Israelite as he proved himself to be.

THE BUNSEN LAMP.

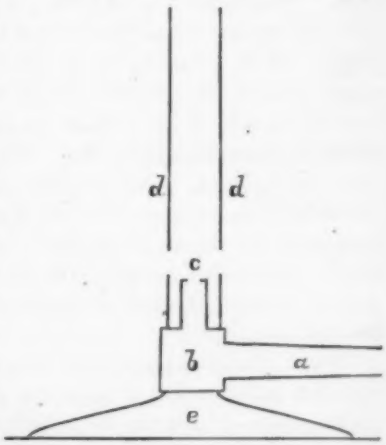
By H. P. ARMSBY.

THE great convenience of gas as an illuminating agent, due to its cleanliness and immediate availability in any desired quantity, soon led to its use as fuel; and to-day we have apparatus of all degrees of size and complexity, from the simple burner of the chemical laboratory to the gas-stove with which the meals of a large family may be cooked, or the gas-furnace capable of melting iron or satisfying the demands of the gold and silver assayer, all using gas as fuel—not to speak of the numerous applications of the waste gases from blast-furnaces and the like, or of the Siemens gas-furnace, using gas made especially for it, and in which the degree of heat that can be

attained is practically limited only by the capacity of the furnace itself to withstand it.

In all or nearly all the applications of illuminating gas to heating purposes, however, a practical difficulty has to be overcome. The gas is made for illuminating purposes, and therefore burns with a bright flame, which deposits a layer of lamp-black, or soot, on everything brought into contact with it. Evidently this difficulty must be overcome before any extensive use could be made of gas as fuel, particularly for those domestic purposes to which it finds one of its chief applications. For practical purposes one of two methods is adopted. One of these is to cause the gas to burn from a number of small openings in a metal pipe. Two effects are thus produced. The large mass of metal in the tubes abstracts heat from the flame, and, as a result, the latter burns mostly blue and produces little smoke or soot; and, secondly, the distribution of the gas into several small flames allows us to place the article to be heated high enough over the flame to avoid the soot, and yet near enough to get a good heating effect. A second and more common method of preventing the deposition of soot is by the use of some form of the Bunsen lamp.

Nearly all the common gas-stoves and other arrangements for heating by gas are essentially Bunsen lamps, more or less modified to suit particular purposes. One of the simplest and most common forms of this lamp is represented in section in the annexed figure. The gas enters through the metallic tube *a*, passes through the block *b*, and finds an outlet through one or more small apertures at *c*. Surrounding *c* is a larger metallic tube, *d d*, having at its base two apertures for the admission of air. The mixed gas and air rise through the tube *d d*, and burn at the top with a pale-blue, smokeless flame. The lamp is supported by a heavy cast-iron foot, *e*.



Though this lamp is of simple construction, the explanation of its operation involves some very curious and interesting facts regarding the theory of flame, as well as some very familiar ones, and in order to comprehend it we shall need to begin with a study of flame in general, and of luminous flames, like that of ordinary gas, in particular.

When a solid combustible, like charcoal, burns in the air, it produces no flame, but simply glows. The blue flame that is often observed playing over the surface of a coal-fire is that of the carbonic-oxide gas

produced in the fire, and not that of the coal itself. *Only gases burn with a flame.* In those cases where a solid or liquid seems to do so, it will be found that it is either volatilized or decomposed by the heat of the combustion, and thus converted into gas before it burns.

Let us now begin our study of the phenomena of flame by considering the flame of hydrogen. Suppose we have hydrogen-gas flowing from a round jet. Just over the opening we have a round column of pure hydrogen. This gas, being lighter than air, and being forced out under some pressure, rises. As it rises it mixes with the air, and we immediately have, surrounding the jet of hydrogen, a layer of mixed hydrogen and air which is inflammable. If we now apply a light this mixture takes fire. The hydrogen unites with the oxygen of the air, forming steam, which is carried away by the current of hot gases; more hydrogen is continually supplied from the jet, and more oxygen from the atmosphere: and thus we have a continuous formation, as fast as it is burned, of this inflammable mixture of hydrogen and oxygen around the central column of hydrogen.

Evidently, then, the flame must be hollow. That it is so may be shown by the familiar experiment of quickly inserting the phosphorus end of a match into the center of the flame, where it may sometimes be held until the wood of the match is burned through without taking fire. The flame can not spread inward, because there is nothing there to support combustion; nor outward, because there is nothing there to burn. The flame is simply that part of the current of gases where the chemical action takes place, and where, consequently, the heat is produced. It is more nearly a *place* than a *thing*. If we leave out of account for a moment the chemical changes, we may compare the current of gas which flows from the tube to a metallic rod which is being slowly pushed through a fire. The portion in the fire glows, and, as the rod moves on, different portions of it glow, while the glowing spot, which may be compared to the flame, remains stationary. In the hydrogen-flame the rod is of gas and invisible. We see only the spot which glows, and, as this is stationary, we are apt to regard it as an object by itself, instead of considering it as a spot in a constantly flowing stream.

The hydrogen-flame gives out very little light. If burned from a metallic jet, the flame becomes almost invisible. What little light such a flame does emit, it emits because the gases of which it is composed are hot; but ordinary gases, when heated to the temperature of a flame, emit very little light.

To render a flame luminous in the sense in which an ordinary gas-flame is luminous, we must introduce into it some solid which is not converted into gas at the temperature of the flame. The light of a common gas-flame is due to innumerable small particles of carbon, which are separated from the gas in the interior of the flame and are heated white hot while passing through the flame. Illuminating gas

consists practically of compounds of carbon and hydrogen. The gas must get very hot before it actually begins to burn, and it is a well-known fact that at a high temperature some of the compounds contained in it are decomposed, with separation of carbon.

In the interior of the flame, likewise, the *compound* of carbon and hydrogen is decomposed, and yields a *mixture* of carbon and hydrogen. The hydrogen burns with a colorless flame, but the solid particles of carbon, as they float through the flame, are heated white hot, and furnish the light of the flame. Finally, as these glowing particles reach the outside of the flame, where there is more air, they also burn, evolving still more light.

We are now prepared to study the ways in which such a flame may be converted into what is frequently called a "non-luminous" flame, by which is meant, not a flame that gives out *no* light, for no such flame exists, but one which emits only the faint light of incandescent gases. For brevity I shall use the term "non-luminous" in this article.

A luminous flame may become "non-luminous" from three causes:

1. Cooling.
2. Dilution of the gas or the air.
3. Too rapid oxidation of the separated carbon.

1. Cooling.—The gas in a flame must be heated to a certain temperature in order that carbon may be separated from it in the manner described.

If the heat of the flame is reduced below this point, no separation of carbon takes place, the flame contains no solid matter, and becomes "non-luminous." For example, if a small gas-flame be caused to play against a cold platinum dish, the flame is spread out over the surface and becomes "non-luminous." The dish, being cold, abstracts so much heat from the flame as to render the separation of carbon impossible. If the dish be heated by a gas-lamp held on the other side, this loss of heat by the flame is checked, and it at once becomes luminous again. A familiar example of the effect of cooling a flame is seen when an ordinary gas-flame is turned very low. Heat is abstracted from the flame by the cooler burner and conducted away, and the result is a small blue flame, emitting scarcely any light. The blue space in the lower part of an ordinary flat gas-flame is likewise due in part to the cooling effect of the burner and in part also to the rush of cold gas into the flame. That this is so is shown by heating the burner, by which means the area of the blue space is notably diminished.

Exact experiments with the photometer have shown that considerably more light is emitted when the gas burns from a red-hot burner, while the consumption of gas is rather diminished than increased. It might seem from these facts that burners of lava, or some similar substance, would have a decided advantage over burners of metal, in regard to the amount of light obtained, since lava is a poor conductor

of heat, and would therefore not convey away the heat of the flame so rapidly as metal. Experiment shows, however, that the difference is very slight. It is measurable, but not of practical importance. The practical value of a lava-tip lies simply in the fact that it does not rust. Neither are any arrangements for heating the burner likely to effect any gain in illuminating power. Obviously the heat for this purpose must not be taken from the flame itself, but must either be obtained from its waste heat or from a separate source of heat. The waste heat of the flame would probably not heat the burner hot enough to produce any appreciable effect, while a separate source of heat involves additional expense enough to overbalance any gain likely to accrue.

A flame may be cooled in another way than by means of some cold body held in it, namely, by mixing some indifferent gas with the combustible gas. If, instead of air, a stream of carbonic-acid gas be admitted at the bottom of a Bunsen lamp, the flame becomes "non-luminous." We get the same amount of heat in the flame as before, since we burn the same amount of gas; but this heat has not only to be applied to heating the illuminating gas and the products of its combustion, but has also to heat the carbonic-acid gas. As a consequence, no part of the flame can be so hot as it was before, and the separation of carbon does not take place.

If the tube through which the gases pass be heated, the heat thus added counteracts the cooling effect of the carbonic-acid gas, and the flame becomes luminous again.

2. Dilution.—The second way in which we may render a gas-flame "non-luminous" is by dilution, either of the gas or the air. This can be shown by substituting for the carbonic-acid gas some combustible gas which does not give a luminous flame; for instance, carbonic-oxide gas. This gas can not essentially lower the temperature of the flame, for it burns with as hot a flame as gas, yet the mixture of it with illuminating gas gives a "non-luminous" flame. Plainly, then, we must conclude that simple dilution is able to produce this effect. Apparently such a mixture as this—that is, a mixture of two gases, one of which burns with a luminous and the other with a "non-luminous" flame—requires to be made hotter in order to produce a separation of carbon, and consequently a luminous flame, than does the illuminating gas when burned alone. If we raise the temperature of the flame by heating the burner, it becomes luminous again. Dilution, then, renders a flame "non-luminous," because the temperature of the flame is not high enough to cause a separation of carbon from the *diluted* gas.

3. Too Rapid Oxidation of the Carbon.—The third method of rendering a flame non-luminous is to supply it with so much oxygen that the carbon is burned at once before it can separate in the solid form.

If we put a small gas-flame into a jar of pure oxygen it is rendered

"non-luminous." This effect can not be caused by cooling, for the greater supply of oxygen makes the flame hotter, nor by dilution, for nothing is diluted. Evidently it must be caused by the greater supply of oxygen. The air contains four volumes of nitrogen-gas for every one volume of oxygen. When a substance burns in air, the particles of oxygen are hindered in getting at the combustible by the particles of nitrogen, which are four times as numerous. When the substance burns in pure oxygen there is no trouble of this sort, and the combustion takes place much more rapidly and energetically. Such is the case in our experiment. The oxygen-particles are no longer hindered in getting at the carbon by the inert nitrogen, and therefore seize on it so promptly as to leave none to make the flame luminous. If we allow the carbonic-acid gas, resulting from the burning, to accumulate in the jar, this gas will perform the function of the nitrogen of the air. At first a very bright spot appears in the center of the flame where the least oxygen penetrates. It is brighter than a gas-flame in air, because the more rapid combustion makes the flame hotter, and consequently the little particles of carbon glow more intensely. As the carbonic-acid gas accumulates, it becomes more and more difficult for the oxygen to get at the flame. When four fifths of the gas in the jar are carbonic acid, the flame burns as it does in the air. As the carbonic acid still goes on accumulating we get another effect, viz., that of dilution, and the flame becomes "non-luminous" again. In this experiment are illustrated all three of the causes which render luminous gas-flames "non-luminous." At first we observe that the combustion is so rapid that no carbon is separated. At the close of the experiment we see the flame become "non-luminous" again on account of the dilution of the air with inert gas and the attendant cooling of the flame.

If we try this same experiment with a flame which owes its luminosity to incombustible solid particles, or to vapors, we shall get only the effect of the greater heat of the flame. For example, hydrogen-gas containing a small proportion of the vapor of chromyl chloride burns with a luminous flame, the light being due to the separation in the flame of particles of solid oxide of chromium. If this flame be placed in pure oxygen it becomes of an almost dazzling brilliancy. The particles of oxide of chromium are incombustible, and therefore the greater heat of the flame only makes them glow the more brightly. This experiment shows that a flame becomes hotter in pure oxygen than in the diluted oxygen of the air, and furnishes an indirect proof that the reason why a gas-flame is made "non-luminous" in oxygen is because its carbon is burned up so quickly.

We distinguish, then, two effects produced on a luminous gas-flame by pure oxygen. First, it makes the flame hotter, and consequently tends to make it brighter; and, second, if the supply of oxygen is relatively large, it burns up the carbon of an ordinary flame at once, and thus renders the flame "non-luminous."

Having now considered the three causes which may convert the luminous flame of our common street-gas into a faint and so-called "non-luminous" flame, we are prepared to trace the operation of these causes in the Bunsen lamp. All the various forms of the Bunsen lamp burn a mixture of gas and air. Now, the air is itself a mixture of four parts of nitrogen with one part of oxygen. The nitrogen of the air takes no part in the process of combustion, but simply passes unchanged through the flame. It is plain that this nitrogen must act on the flame in two ways. First, it must cool it, just as any cold substance passing through the flame would cool it; and, second, the nitrogen dilutes the illuminating gas. The effect of both cooling and dilution, as we have seen, is to make a flame "non-luminous."

But one fifth of the air is oxygen; and this also has two effects upon the flame. It makes it hotter, and it also tends to burn up the carbon of the illuminating gas at once, before it can make the flame luminous. All these causes cooling, dilution and oxidation of the carbon are operative at once in the Bunsen lamp, and the effect that we see is the resultant of all these forces. Probably the most important of them are the cooling and dilution by the nitrogen; for, if the burner through which the gases issue is heated, the flame becomes luminous again.

The Bunsen lamp takes various forms, according to the purpose for which it is to be used. In some of these the gas burns on the top of a piece of fine wire-gauze, after becoming mixed with the air below it. This form of burner is a very common one. It differs in appearance from the usual form of Bunsen lamp, but is essentially the same in principle; that is, it burns a mixture of gas and air, and gives a "non-luminous" flame for the same reasons that the ordinary Bunsen lamp does.

THE COLORADO DESERT.

By JOSEPH F. JAMES.

THERE is an old adage which says that Arizona was the last spot on earth to be created; that Yuma is the outpost of the nether regions, and the hottest place in the world. Every one knows the old story of the two soldiers who, while stationed at Fort Yuma, died, and, going straight to Hades, returned in a short time for their blankets! Be that as it may, there can be no doubt that parts of Southern California and Arizona are among the hottest regions of the world. Neither the Desert of Gobi in Asia nor the Great Sahara in Africa can be worse, in this respect, than their small relative, the Colorado Desert, in California. A protracted journey of some four weeks over this desert gave me an excellent chance to see it and its

worst aspect, and I purpose trying to give others an account of its most interesting features.

The desert occupies almost the whole of the large county of San Diego. It is some one hundred and fifty miles long and fifty miles wide, and the Southern Pacific Railroad runs through the center of it. About sixty miles from Los Angeles, the railroad encounters a very heavy grade, one hundred to one hundred and ten feet to the mile, and it continues for twenty-two miles. At the summit, known as San Gorgonio Pass, begins the descent into the desert, and every mile brings you to a more desolate country. At Whitewater Station, twenty miles from the summit, the desert commences in earnest. First a few flowers enliven the scene. Large *Œnotheras*, three or four inches in diameter, grow on small stalks five or six inches high. Large plants of *Abronia maritima*, with clusters of brilliant purple flowers, spread over the ground. A little *Gilia* (*G. Lemmoni*), with white corolla and yellow center, adds its beauty to the scene; and the only shrub, *Larrea Mexicana*, or creosote-plant, with yellow flowers and sticky leaves and branches, reminds you of the forests you have left behind.

During the seven miles to the next station, known as Seven Palms, the vegetation gradually thins out. As we progress beyond, the flowers disappear, and cacti predominate, and farther on these are replaced by the stunted grease-wood. Finally, even this vanishes, and when Dos Palmas is reached we have come to a country where there is absolutely nothing in the shape of vegetation. Every one knows how a well-kept field looks when it has been plowed, and harrowed, and cultivated until not a stick, nor a stone, nor a weed shows itself above-ground. Well, in order to form a picture of this part of the Colorado Desert, imagine a field such as this extending for miles and miles, level as a floor, with no signs of life visible, and no indication of man's presence save the railroad-track and the telegraph-poles. Imagine the ground covered with an incrustation of alkali, which, when stepped on, breaks, and lets one sink ankle-deep into soil as soft and fine as powder. Picture to yourself a gale of wind blowing over the waste, the air filled with fine particles of sand, the sun obscured, and no objects visible one hundred feet away, and you will have formed a faint idea of the worst aspect of the desert.

But it is hard to imagine anything so fearful as the reality, and unless one can see the ground, and feel the sand, and experience a heat of 120° in the sun, one can have only a poor conception of the desert. Every one knows the efficacy of the sand-blast. In no place in the world can its effects be better seen than on this desert. The telegraph-poles are polished on one side as smooth as glass. The white paint on the sign-posts is worn off as clean as if scraped and rubbed with sand-paper. Many of the ties, and the timbers of small bridges and culverts along the railroad, look as if some industrious

Dutch housewife had washed and scrubbed them with soap-and-water, until they resemble in their whiteness the boards of her own kitchen-floor. Glass bottles, left for a short time on the ground, lose their original appearance, and are ground inside and out. All this is the effect of the blowing sand.

Here, at the station of Dos Palmas, we are some two hundred and seventy-five feet below the level of the sea. The heat in summer is simply fearful, and this, added to the sand-storms, makes it anything but a desirable place of residence. Men can only be induced to work on the railroad by offering them increased wages. All the section-houses along the road (and for nearly two hundred miles there are no other habitations) are built in a peculiar manner. None are more than one story high. Each has a large porch at one side and a double roof. The lower one constitutes the ordinary roof, but the upper one is raised up about two feet, and the eaves project some four feet beyond the walls. This arrangement, leaving an open space between the two roofs, admits the circulation of air, and keeps the interior of the house cooler than it would otherwise be. Such precautions will be thought to be by no means extraordinary, when it is known that 95° to 100° is the ordinary temperature in a shady spot, and 115° or 120° is by no means uncommon.

Rain never falls on this desert in the natural manner. Cloud-bursts and water-spouts, accompanied by fearful thunder and lightning, are of frequent occurrence. The ground between Frink's Spring and Flowing-Well Stations, a distance of seventeen miles, is cut and gullied in a most remarkable manner. In this distance there are no less than seventy-five bridges and culverts on the railroad-track. The gullies vary from five to twenty-five feet in depth and about the same in width. The banks are so steep and precipitous that, in walking along, one does not see the cañon until it yawns at one's feet. These gullies are all caused by the rush of water from cloud-bursts and water-spouts.

Some six miles from Frink's Spring Station is a section-house known as Volcano. Close to it, and a few yards from the track, is a mud-spring, and from this the house takes its name. The spring is situated in a depression about twenty-five feet deep, and the same in diameter. In the bottom is a small lake, or mass of liquid mud. This rises in great bubbles as large as a hat, breaking and sputtering like boiling lard. All over the surface of the water are little bubbles, caused by carbonic-acid gas. Both mud and water have a strong smell of sulphuretted hydrogen, and the spring is evidently the result of volcanic force, which has, at some former period, been very active.

At Flowing-Well Station there was, when the railroad was first put through, a well bored to get water to supply the locomotives. The surface-water, all through the desert, is so alkaline that it is impossible to use it. It is, therefore, necessary for the railroad to haul water

on every train for about a hundred miles. Trains going both ways take one or more tank-cars, for the supply of section-hands and engines. In the well referred to, water was finally reached, and in such quantities that the flow could not be stopped. It ran for three days, flooding the whole country for miles around, and then stopped, and has not run since. The water of this well had the same sulphur taste and smell as that now found at Volcano.

Just beyond Flowing-Well Station, the road runs along a chain of most desolate sand-hills. These continue for twenty miles. During severe winds, which are of frequent occurrence, the sand drifts over the track very rapidly, and in a few hours covers it to the depth of a foot or more. It has been found necessary to have a relay of men constantly on the ground, and every day they are engaged in clearing the track. The engineers are warned of their approach to these bad places by large posts, with the word "sand" painted on them, and must then take extra care.

There are many things to indicate that at one period the lowest portion of the desert was covered with water, forming an extensive lake. In places the character of the soil is such that there can be no doubt that it was deposited in still water. It is as soft and fine as powdered chalk, and not a stone can be found for long distances. We pass in one place, quite suddenly, from a gravelly, stony soil to one which is neither. It seems to mark the shore or boundary of the lake, and here the ground is covered with shells of various species. *Anodonta Californiensis*, *Amnicola longinquas*, *Tryonea protea*, and *Physa humerosa*, are very common, and all of them are living in Western waters at the present day. Then, again, we come to piles of stones, all water-worn, and showing the former presence of water where now there is not a drop.

Where has the water gone to? There can be no doubt that volcanic action has had much to do with its disappearance. Black, lava-like stones are found in huge streams, as they might be called, extending for miles. Pumice-stone is found in large quantities in many places, and great blocks of lava are said to lie at the foot of the mountains bordering the desert, some twenty-five miles away. The presence of the volcanic spring, already referred to, is corroborative evidence of volcanic action. There is still a large body of salt-water lying at a considerable depth under the surface. At Mammoth-Tank Station the railroad company has been engaged for some time past in boring a well. They had reached a depth of thirteen hundred and fifty feet at the time I passed, and had then found nothing but salt-water.

It is curious that the various stations on the road have been called after things nowhere to be seen in their immediate neighborhood. Seven Palms takes its name from a group of trees fifteen miles away toward the mountains. Flowing Well is very dry. Mesquite has not

a bush of any consequence anywhere near, though they are common enough near Indio. Frink's Spring has no water within six miles; and at Cactus, strange to say, there is hardly a plant in sight.

The animal life in the desert is meager in the extreme, and in many places there is none at all. Along one stretch of twenty miles, where there are no trees of any size, the woodpeckers and little wrens have made their nests in holes dug in the telegraph-poles. It is strange that the habits of these birds have not been modified to suit the surroundings, but they have probably come into the country since the poles were erected. Snakes are in places comparatively common, but still, one might travel for two or three days and not see any. Rattlesnakes live under the stones, and resemble the ground so closely that they are hard to distinguish. Lizards delight in the hot, sandy wastes, and at all times are darting hither and thither with the rapidity of light. In places are regular beaten tracks made by them along one side of the rails. Horned toads, really lizards (*Phrynosoma cornutum*), are common, and so near the color of the sand that it is almost impossible to recognize them except when running, and utterly impossible to catch them. Three or four kinds of beetles are common in places. *Cryptoglossa verrucosa*, *Cysteodema armata*, and *Endrotes ventricosus*, are the most common. The first has such hard *elytra* that they can almost be stepped on without fear of crushing them. They generally take refuge from the sun on the shady side of the rails, and the tracks left by them are plainly visible. Great numbers are found dead on the sand, and it would seem that the heat of the sun and of the sand combined was too much for them. The much-dreaded scorpion and the centiped are also found, but are not common.

The vegetation of the desert is, of course, of a peculiar character. For about twenty miles near Indio, the mesquite (*Prosopis juliflora*) is very common. It forms a tree twenty or thirty feet high, with a very rough bark, scraggy branches, and sharp thorns. The leaves are like those of the acacia, and the flowers yellow, in long racemes. The pods succeeding the flowers are long and crooked, and are used by the Indians for food. The branches are often burdened by huge masses of mistletoe, sometimes as large as a barrel, and serve as nesting-places for birds. The mesquite-wood is excellent for fires, and the Indians cut and stack it along the road to sell to the company for fuel.

Cacti are common over a large part of the desert, and the brilliant crimson and yellow flowers serve to enliven the otherwise desolate wastes. *Larrea Mexicana*, the creosote-plant, is also common. It is so called on account of its peculiar odor. The leaves are small and sticky, the flowers yellow, and the seeds are covered with a whitish fuzz. Nothing will eat it, it is unfit for burning, and it is hard to tell what place it fills in the economy of nature. The *Parkinsonia Torreyana* is another peculiar desert-plant. The Spaniards call it "palo

verde," on account of the pale-green color of the branches. The blossoms are of a bright yellow, hang in long clusters all over the tree, and are visited by great numbers of wild-bees for the honey they contain. When in blossom there are no leaves on the trees, these coming out afterward, small, awl-shaped bodies, almost invisible to the eye. It would seem that the branches serve the purpose of leaves, and probably contain the stomata, in the same way as do the trunks and branches of the cacti. The *Fouquieria spinosa*, the "ochotilla" of the Mexicans, is one of the most remarkable of all the desert-plants. The stem or trunk is very short, and branches into a number of long, lithe, whip-like shoots, covered with curved spines an inch or so long. The flowers are bright red, forming clusters at the ends of the shoots, and are succeeded by oblong capsules filled with minute seeds.

When the borders of the desert are reached, and we catch the first glimpse of the Colorado River near Yuma, the eye rests with delight upon the broad, rolling stream, and the banks lined with mesquite-trees. No one can fully appreciate the beauty of forest vegetation unless he has spent some time on a desert waste, where even water to drink is scarce, and where vegetation of any consequence is unknown. The mesquite-trees along the Colorado are quite large, and the Yuma Indians find a considerable store of food in the beans.

It is surprising to a stranger to see these Indians walking round in the sun without any head-covering except their hair, and nothing whatever on their feet, with the sand hot enough to scorch the skin of any one unaccustomed to it. They are not bothered with clothes, the braves at all events, for their dress is often solely a breech-clout about the waist, or occasionally a thin under-shirt in addition. Some have finely-formed figures, straight as an arrow, and, with their bronzed skin, look almost like statues when they pose. They are a worthless set, however, and live upon what they steal or find on the trees or take from the river. The squaws do the household work and carry wood and water, while their lazy lords spend the time roaming about or sleeping in their tents.

The Colorado River at Yuma is a good-sized stream. The water is very muddy, and, even when settled, has a milky tinge. It is, nevertheless, very good to drink, being, in fact, the best in the country. The stream is navigable for small steamers for about three hundred and seventy-five miles above Yuma, but in low water the boats often run aground on the sand-bars, and have to be stilted over them with timbers. An old navigator said that sometimes it was necessary to turn the bow down-stream, start the engine backward, and use the paddle to dig a way over the shallow places!

Yuma itself is situated in a hollow, surrounded on three sides by sand-hills. No breeze can cool the air, and the sun, beating down with almost tropical fervor, often causes the thermometer to register 120° in the shade. Even at night it is hot, for the earth radiates the heat

received during the day, and the inhabitants find it almost unbearable. Many sleep on the house-tops, and many more on the sidewalks in front of the houses, making their morning toilets in the open air. The houses are built of adobe or mud-bricks, with heavy walls and flat roofs, all of them but one story high. Taking everything into consideration, Yuma is not a place to have a summer residence in, however pleasant it may seem to one after a four weeks' journey over the Colorado Desert.

PROFESSOR JOHN W. POWELL.

PROFESSOR JOHN W. POWELL, better known as Major Powell, Ph. D., founder and director of the Bureau of Ethnology of the Smithsonian Institution, and present director of the United States Geological Survey, is a pattern of the American self-made man, and well illustrates in his life and achievements what may be accomplished with honest, steady adherence to a definite purpose. He was born at Mount Morris, New York, on the 24th of March, 1834, a short time after the arrival of his parents from England. His father was a Methodist clergyman, and was required to lead a very unsettled life. In his early childhood the family removed to Ohio ; eight years afterward, to Wisconsin ; and again, when he was fifteen years of age, to Illinois, where young Powell remained most of the time until the breaking out of the war.

It was during this latter period that his mental characteristics were developed. He was eager for knowledge, and used every opportunity to pursue such courses of study as were accessible to him, or appeared to be adapted to his case. He studied for a time at Illinois College, Jacksonville, and subsequently entered Wheaton College. Unable to attend school continuously, he alternated between teaching in the public schools and studying, and in 1854 he went to Oberlin to pursue a special course of two years.

From the first he was strongly attracted to the natural sciences, and particularly toward natural history and geology. He was fond of making collections, which he studied for their own sake. He commenced with botany, to which he has made some valuable contributions. Being much interested in nature, he acquired a roving disposition, and lost no opportunity of making scientific excursions, sometimes extending to long journeys. Having already made journeys on the Mississippi to St. Paul and across the State of Wisconsin to Mackinaw, in 1856 he descended the Mississippi River in a skiff and alone from the Falls of St. Anthony to its mouth, making collections, which he gave to the various museums of the State institutions. The next year he rowed from Pittsburg to the mouth of the Ohio,

and spent the fall in Missouri, studying the geology and mineralogy of the Iron Mountain region. In 1858 he made a trip from Ottawa, Illinois, down the Illinois River to its mouth, and later ascended the Desmoines River, returning laden with specimens.

The various institutions of the State of Illinois, and some of other States, soon came to depend upon his collections for illustrating their courses of scientific lectures, and the Illinois State Natural History Society elected him its secretary, and extended to him facilities for prosecuting his researches, now recognized as of high value. The funds necessary for conducting these operations he was obliged to obtain by teaching a portion of each year.

The breaking out of the rebellion put a temporary check upon Professor Powell's scientific adventures. He enlisted as a private in the Twentieth Illinois Infantry. Having been made a lieutenant, he was transferred to Battery F, Second Illinois Artillery, and was afterward promoted to be captain of the battery, then major of the regiment, and finally lieutenant-colonel. In the last days of the war he received a commission as colonel, but, having no desire to follow war as a profession, declined it.

At the battle of Shiloh he lost his right arm. As soon as he had sufficiently recovered from his wound he returned to his post, and continued to serve to the end of the war.

His passion for collecting did not forsake him even while in the army, and wherever he was stationed for a sufficient length of time he found means of studying the geological formations, and of shipping from time to time to the State Museum large invoices of valuable material.

On his return from the army he was offered a lucrative civil position in his own town of Wheaton, but he preferred to accept the comparatively unremunerative one of Professor of Geology and Curator of the Museum of the Illinois Wesleyan University at Bloomington. This he afterward exchanged for a similar post in the Illinois Normal University.

In the summer of 1867 Professor Powell, taking with him his class in geology, visited the mountains of Colorado for the purpose of study. This excursion was the first attempt of its kind in this country, and to Professor Powell is therefore due the credit of having inaugurated a practice of the highest value to science and to education, which has been continued by many eminent teachers at leading institutions, until a certain amount of field-study has become recognized as a necessary part of a course of instruction in all branches of natural science.

Professor Powell saw more in the parks and cañons of Colorado than a mere training-school for students. He saw, stretching far westward and southward, a vast unexplored region, hitherto represented on all maps by an utter blank, and through which at some point must flow an immense river, the Colorado of the West, whose

upper tributaries and lower portion were alone known to civilized man. That such an unexplored region should exist within the limits of the United States seemed to him almost a reproach to the boasted enterprise of our people, and he began to lay plans for its exploration.

In the summer of 1868 he organized a party of men, some of whom were mountaineers, and, starting from Middle Park, followed down the Grand River to the head of Cedar Cañon, thence over the Park Range through Gore's Pass to the White River, one hundred and twenty miles above its mouth. Here the party went into winter-quarters, and during the winter made reconnaissances, and completed their preparations for an early expedition in the spring.

Proceeding, in the spring of 1869, to Green River station, on the 25th of May the expedition launched its four small craft in Green River, the largest of the tributaries of the Colorado.

We have not space to follow them through their perilous voyage of over three months' duration, or to describe the succession of hardships, disasters, and hair-breadth escapes, by which almost every day of this period was characterized. All this has been written by the hero of the expedition. We can only say here that it was not until the 20th of July that the brave party reached the junction of the Grand and Green, or the head of the Colorado River proper; that on the 13th of August they entered the Grand Cañon, from which they did not emerge until the 29th; and that on the 30th of that month they at last arrived at the mouth of the Rio Virgen, where, for the first time, they saw the faces of white men.

After having been two weeks in the Grand Cañon, already for some time reduced to half-rations, three of the men refused to go farther, and endeavored to induce Major Powell to turn back. He explained to them that they were very near the end of their journey, but was himself almost tempted, in view of the scarcity of provisions, and the probable nearness of Mormon settlements, to yield to their arguments. He passed a sleepless night, and expresses the result of his reflections in the following words: "But for years I have been contemplating this trip. To leave the exploration unfinished, to say that there is a part of the cañon which I can not explore, having already almost accomplished it, is more than I am willing to acknowledge, and I determine to go on." The three men undertook to reach the settlements by a journey across the country, and were murdered by Indians; the boatmen emerged the next day in safety from their granite prison.

This daring voyage was not a barren adventure. In many respects it was a scientific expedition, and as many instruments as could be taken were carried, and determinations were made wherever practicable, the accurate records of which were kept in duplicate, so that one set was safely brought through. The importance of Professor Powell's labors, and their thorough and scientific character, made it apparent that they should be followed up, while their national bearing sug-

gested to Professor Henry, of the Smithsonian Institution, the propriety of asking the Government to lend its assistance.

Accordingly, a topographical and geological survey of the Colorado River of the West and its tributaries was inaugurated by Congress and placed under Professor Powell's direction.

With these added facilities the exploration was pushed from year to year with great energy and success, and a systematic survey was conducted, until all the streams, mountains, plateaus, and other physical features of the Colorado Valley, embracing an area of nearly one hundred thousand square miles, have become thoroughly known topographically and geologically, and there is no longer an unexplored region within the confines of the United States. In 1875 Professor Powell published some important chapters "On the Physical Features of the Valley of the Colorado," which, while dealing largely in the physical geography of the country, were in the main geological, and set forth for the first time the fundamental principles that underlie the structural formation of a large part of the Rocky Mountain region. The next year appeared his "Geology of the Uintah Mountains," which is likewise a model of clearness, and consists in a careful analysis of the laws which have operated in the formation of these masses; while much of the consistent reasoning from the closely observed phenomena of this region is equally applicable to all parts of the West.

So great was the general interest at this time in acquiring an accurate acquaintance with the Western portion of the country, that no less than four authorized surveys were operating simultaneously in the different Territories. These were: 1. The special survey of the fortieth parallel, under the War Department, in charge of Mr. Clarence King, organized in 1867; 2. Dr. F. V. Hayden's geological and geographical survey of the Territories, organized and operating under the direction of the Secretary of the Interior since 1867; 3. A military and topographical survey, conducted by Lieutenant G. M. Wheeler, under instructions from the Chief of Engineers of the War Department, organized in 1869; and 4, and last in chronological order, that of Major Powell, which received its first national aid in the year 1870, although, as we have seen, it had been in the field as a private enterprise since 1868.

These various expeditions became to a great extent rivals, and, being not only independent of each other, but conducted by different departments of the Government, it was impossible to avoid the duplication of much of the work, or to prevent the growth of discordant methods. Occasional collisions occurred between parties of different surveys in the field, bitter feelings were engendered, and the two departments under which the parties were serving found themselves called upon to defend their jurisdiction and claims to the right of conducting public surveys.

The attention of Congress was called to the matter, and on the 15th

of April, 1874, the House of Representatives adopted a resolution asking information from the President respecting the surveys that were operating in the same and contiguous areas of territory west of the Mississippi, and whether it would not be practicable to consolidate them under one department, or to define the geographical limits to be embraced by each.

The President's message in reply to this resolution was accompanied by a report from the Secretary of War, who transmitted the views of the Chief of Engineers, and one from the Secretary of the Interior, transmitting in like manner sub-reports from the heads of the respective surveys under his superintendence, viz., Hayden and Powell. Upon the question of consolidating all the surveys then in operation under one department, but one opinion was expressed, all being in favor of such a measure; but, as to which department should control them, the views were discordant—the President, the Secretary of War, and the Chief of Engineers, urging the claims of the War Department, and the Secretary of the Interior and both the heads of surveys under his direction as firmly advocating the fitness of that department to administer them. The War Department claimed this right by a sort of *prescription*, as it was under its protection and control that all the early explorations, including the celebrated expedition of Lewis and Clarke, had been conducted, and by it the leading object was declared to be the accurate mapping of the country for military operations. It also claimed a higher scientific training and discipline for performing the work.

The Department of the Interior, on the other hand, connected the surveys primarily with the public domain, and showed that they were chiefly ancillary to the operations of the Land-Office, which had always been under that department. It also maintained that even in the expeditions under the Engineer Corps civilians had always performed the bulk of the scientific work.

The committee to which the reports were referred recommended that the surveys under the War Department should be continued, so far as they were necessary for military purposes, and that all other surveys for geographical, geological, topographical, and scientific purposes should be continued under the direction of the Department of the Interior.

This report left matters nearly where they were, and was not satisfactory to either party. A second inquiry was ordered by the House in March, 1878, and the officers immediately charged with the surveys were again called upon to express their views on the subject. Major Powell, in his statement, pointed out the essential vices of the multiple surveys; proposed that each branch of natural history should be prosecuted wholly by some one of the divisions, which should be in possession of all the materials; offered to turn over to Dr. Hayden all the materials in his possession relating to any or all of these branches,

or to receive and elaborate the materials collected by other surveys; and pointed out the different methods by which the work of surveying was performed by the parties of the War and those of the Interior Department, and the impossibility of ever completely harmonizing them. He also presented a map, showing the amount and location of the duplicated work. His paper concludes with these remarks: "If the surveys of both departments are carried on over the entire region, there will be two general atlases of the whole area, and the work will be twice done. If the surveys are confined to different areas, there will be an Interior Department atlas of one region and a War Department atlas of the other, and neither atlas can be completed for the entire region without reconstructing the maps of the other. In view of these facts, it is manifest that the work should be unified and a common system adopted. This may be accomplished either by an act of Congress, by executive direction, or by placing the work under one management."

The improbability that, in case of consolidation, Professor Powell would be called to the head of the surveys, as well as the known sincerity of his personal character, precluded suspicion of any other motive for such an expression of views than that of concern for the interests of the service.

A provision was inserted in one of the appropriation bills, requiring the National Academy of Sciences to take into consideration "a plan for surveying and mapping the Territories of the United States on such general system as will secure the best results at the least possible cost." Professor O. C. Marsh, president of the academy, and chairman of the committee appointed by it to consider the subject, requested the Secretaries of War and of the Interior to furnish the committee with any data at their disposal to aid it in performing the duty thus imposed upon it. Both secretaries responded through their chosen representatives, Professor Powell, with Dr. Hayden and Commissioner Williamson of the Land-Office, appearing for the Interior Department. Professor Powell's paper was even a more clear and complete statement than the one he had made before the congressional committee, of the necessity of consolidating the surveys and making a division of the labor on a scientific basis. On the 26th of November the National Academy submitted its report, on the basis of the one that had been made to it by its committee, recommending the establishment, under the Department of the Interior, of an independent organization, to be known as the United States Geological Survey, to be charged with the study of the geological structure and economical resources of the public domain, the director of which should be appointed by the President. A provision organizing the survey, in accordance with these recommendations, was passed by Congress in an appropriation bill.

Professor Powell supported Mr. Clarence King, who was appointed

for the position of director of the survey, and was himself placed upon the commission on the codification of existing laws relating to the survey and disposition of the public domain.

The labors of this commission concluded, Professor Powell was glad to be able to turn his attention once more to science. The one field which now most deeply interested him was that of American ethnology. From the very beginning of his Western explorations, the aborigines had strongly engrossed his thoughts, and among all his scientific collections and investigations which he had been enabled to make none had received more careful attention than those relating to the Indian tribes. While the other surveys had devoted much attention to the collection, study, and illustration of the various departments of natural history, he had made ethnography, next to geology and topography, the chief object of his expeditions. Prior to the date of the consolidation, three volumes relating to ethnology had been published by the Powell Survey, and eight more were in different states of preparation, while in addition to this the material collected and deposited in the Anthropological Hall of the Smithsonian Institution was sufficient for several other volumes, and demanded elaboration. The study of Indian languages had especially interested him, for he saw that, whatever success might be attained in preserving the Indians themselves from extermination, the fate of their languages was already settled, and in a short time the primitive stocks would have inevitably become so badly corrupted that the philologist would find it impossible to deal with them in a scientific manner.

Efforts were made by the Secretary of the Smithsonian Institution and the Secretary of the Interior to prevent the discontinuance of this work, and an appropriation of twenty thousand dollars was secured in March, 1879, for completing and preparing for publication the "Contributions to North American Ethnology," under the Smithsonian Institution, with a provision that all the material collected in the surveys that bore on that subject should be turned over to that institution.

Professor Powell was put in charge of this department, and has prosecuted it with great vigor and success to the present time. A Bureau of Ethnology grew up under the Smithsonian Institution, which has become the recognized center of ethnographic operations in this country.

When, in the spring of 1881, Mr. Clarence King retired from the work of the surveys, there seemed to be no rival candidate to Professor Powell for the vacant position, and it fell to him as the most obviously suitable person to fill it.

Without mentioning particularly the numerous official reports into which important scientific matters have often found their way, the principal literary contributions of Professor Powell are the following:

1. "History of the Exploration of the Cañons of the Colorado."

This work, which was published in quarto form and illustrated, as Part I (Chapters I to IX) of the original volume of "Exploration of the Colorado River of the West and its Tributaries, explored in 1869, 1870, 1871, and 1872, under the Direction of the Smithsonian Institution" (1875), consists of the personal narrative, from Professor Powell's diary, of the celebrated voyage down the unexplored river.

2. "On the Physical Features of the Colorado Valley." This forms Part II of the same work.

3. "Geology of the Uintah Mountains, with Atlas" (1876).

4. "Introduction to the Study of Indian Languages, with Words, Phrases, and Sentences to be collected" (1877).

5. "Report on the Lands of the Arid Region of the United States, etc., with Maps" (1879). This is a highly important public document, and one with the contents of which the country generally should be familiar. Though containing able chapters by Mr. G. K. Gilbert, Captain C. E. Dutton, Professor A. H. Thompson, and Mr. Willis Drummond, Jr., it is, in its general plan and in the chief part of its matter, the work of Professor Powell.

6. "Introduction to the Study of Indian Languages, etc. Second edition—with Charts" (1880). We enter this work as distinct from the first edition, published in 1877 under the same title, because, with the exception of the schedules, notes to collectors, and remarks on the alphabet, its matter is wholly new. Though small, it is one of the most important of Professor Powell's contributions to science.

Professor Powell is a member of the National Academy of Sciences and a Fellow of the American Association for the Advancement of Science, and presided over the Biological Section of the latter in 1879. He has been the President of the Anthropological Society of Washington since its organization, and his annual addresses before it are published in its "Transactions."

Personally, he is of most agreeable manners, frank, genial, and cordial under all circumstances, and possessed of great individual magnetism. Though social by nature, he has a strong preference for persons of culture, and especially of independence of thought, as his friends, and seems to possess the tact of securing such without giving offense to others. It is a favorite theory of his that, to observe well, one must also think deeply, and that observation without theory is necessarily sterile; and these ideas he carries into practical affairs in the selection of his assistants in all branches of his service. His mind is in the highest degree realistic, and he looks upon all classes of phenomena from the objective point of view. In anthropology he belongs to the strictly scientific school, represented by Mr. Lewis H. Morgan, which rejects the imaginative and poetical accounts of the lower races. He accepts the doctrine of evolution, but has not failed to perceive inadequacies in the systematic developments which some of its disciples have sought to make of certain of its minor details.

ENTERTAINING VARIETIES.

—— The moral responsibility of some animals seems less doubtful than that of "intermittent lunatics." If it should become the duty of a public attorney of the future to prosecute a homicidal monkey, the following case (quoted in Brehm's "Thierleben") would furnish an ugly precedent against the counsel for the defense: A few years ago Dr. Schomburg, the Superintendent of the Botanic Garden of Adelaide, Australia, took charge of a select corps of monkeys and kangaroos, a "happy family," he might have called them, if it had not been for the depravity of an old babuina, or female Bhunder baboon. If she had not been the only representative of her species, he would have tried to get rid of her, for her only object in life seemed to be to make herself as disagreeable as possible. Solitary confinement made her wildly obstreperous, but in the family cage she kept the marsupials in a delirium of terror, and in the evening when her younger relatives ventured to enter the sleeping-box she seemed to consider herself divinely ordained to remove them by force. But one day she attacked her own keeper, and without any apparent provocation lacerated his wrist in a shocking way. Schomburg at once ordered her to be shot. The next morning the assistant keeper approached her cage with a shot-gun, which had often been used to shoot the rats that infested the menagerie-building. The other monkeys seemed to expect another *razzia*, but the Bhunder knew better. The moment she saw the gun she made a dash into the sleeping-cage, and when the keeper tried to open the door she yelled as if she hoped to get off on a plea of insanity. Meaning to try her, the keeper waited till breakfast-time, but the babuina did not show herself. She kept out of sight a full hour, till the mess-boy brought an extra lunch of sliced pumpkins, when she made a rush for the bucket in hopes of securing a portable piece. In that moment the keeper bolted the door of her sleeping-cage, and went back for his shot-gun. As soon as the babuina caught sight of him she flew toward her place of refuge, and, finding the door locked, made a mad attempt to squeeze herself through the interspaces of the front railing. But the bars proved inflexible, and, after another desperate pull at the sleeping-cage door, the babuina flung herself into a corner, closed her eyes, and was apparently dead with fear before the buckshot struck her.

—— Everybody has heard of the *Talmud* (which means *a study*), a venerable work of Hebrew lore, traditions, and commentaries, in twelve folio volumes. There have been many editions of it, and many books about it by renowned scholars. According to the "Encyclopædia Britannica," this is the way the Talmud puts the legendary trimmings on to the history of Adam: "He was made as a man-woman out of dust collected from every part of the earth, his head reached to heaven, and the splendor of his face surpassed the sun. The very angels feared him, and all creatures hastened to pay him devotion. The Lord, in order to display his power before the angels, caused a deep sleep to fall upon him, took away something from all his members, and, when he awoke, commanded the parts that had been removed to be dispersed over the globe, that the whole earth might be inhabited by his seed. Thus Adam lost his size but not his completeness. His first wife was Lilith, mother of the demons. But

she flew away through the air; and then the Lord created Eve from his rib, brought her to Adam in the most beautiful dress, and angels descending from heaven played on heavenly instruments; sun, moon, and stars dancing. He blessed the pair and gave them a feast upon a table of precious stones. Angels prepared the most costly viands. But Adam's glory was envied by the angels, and the seraph Sammael succeeded in seducing him. The pair were driven out of paradise into the place of darkness, and wandered through the earth."

—— Jérôme de Guise, the "champion *lady-killer*" of the eighteenth century, left among his trophies eight *billets-doux*, framed like pictures, and displaying eight different signatures under as many different petitions for immediate—elopement. Yet the triumphs of that charmer are far eclipsed by the record of Abdallah-ben-Abdol, the father of the Prophet Mohammed. On the eve of his nuptials, says the chronicle of Abulfeda, not less than two hundred virgins attested the poignancy of their chagrin by committing suicide.

—— Anaxagoras, the Rhodian, held that *Earthquakes* are nothing but a sort of cosmic flatulence—winds which have strayed into caverns, where they can not find an outlet. Aristotle ascribes them to vapors generated by the infiltration of water through the fissures of a rocky sea-bottom; and Pliny, to the pressure of air confined in deep caves, and reacting against the collapse of superincumbent rock-strata. But the most ingenious explanation is offered by St. Thomas of Aquinas. Earthquakes, he suggests, may be caused by the struggles of defunct misbelievers trying (by a simultaneous stampede, perhaps) to escape from the pit of torment.

—— *An Accomplished Vandal.*—Some of the "truculent and turbaned Turks" of the fifteenth century were very far from being barbarians. Mohammed II, the destroyer of Constantinople, spoke fluently five Asiatic and two classic languages, had mastered the Arabian system of astronomy, the philosophy of Aristotle, and the theogony of the Sufist mystics, and achieved distinction as a poet and a national historian.

—— *A Vegetable Monument.*—The oldest tree on earth is probably the cypress of Santa Maria del Tule, in the Mexican State of Oaxaca. It is still growing, and, when Humboldt saw it, in 1851, it measured 42 feet in diameter, 146 in circumference, and 282 feet between the extremities of two opposite branches.

—— And so Mr. Darwin has given us a new philosophy of *angle-worms*. We had supposed that this "humble creature" was created chiefly for the use of country-boys as bait when they go a-fishing, and so were always to be conveniently found in the garden; but our indefatigable naturalist says that this despised earth-worm is nothing less than an ameliorator on the surface of the globe—a forerunner and coadjutor of the agriculturist in promoting the conditions of life. This is another revolution of ideas that is making our age so uncomfortable. "Worms of the dust" seems to be, after all, not so bad a thing. The sluggard is bidden to go to the ant and learn wisdom; but, while he is about it, he can profitably call also upon the worm. We give some poetry from "Punch" on this subject, and also "Punch's" portrait of the great Darwinian in his last *rôle*. He has not the elated expression of a triumphant discoverer. It was said of Agassiz that when he had found some new and long-sought marking or feature in a fish he waxed hilarious, and would dance about the room, but Mr. Darwin

appears thoughtfully sad. Having accomplished the descent of man and the ascent of the worm, perhaps he is puzzling himself as to what next.

THE WORM TURNS.

I've despised you, old Worm, for I think you'll admit
  That you never were beautiful even in youth;
I've impaled you on hooks, and not felt it a bit;
  But all's changed now that Darwin has told us the truth
Of your diligent life, and endowed you with fame—
  You begin to inspire me with kindly regard:
I have friends of my own, clever Worm, I could name,
  Who have ne'er in their lives been at work half so hard.

It appears that we owe you our acres of soil,
  That the garden could never exist without you,
That from ages gone by you were patient in toil,
  Till a Darwin revealed all the good that you do.
Now you've turned with a vengeance, and all must confess
  Your behavior should make poor humanity squirm,
For there's many a man on this planet, I guess,
  Who is not half so useful as you, Mister Worm!

—— "What is the correct pronunciation of the name of the German poet Goethe?" It is impossible to reproduce the sound of this name accurately through English letters. A partial approximation may be made, however. Try *Gay-teh*, and you will not be so very wrong.—*Sun.*

So Bagehot is *Bah'-jote;* and Quatrefages, *Kah'-tre-fahj.*

—— There seems to be more sentiment than science in objecting to the study of insects on account of the pain occasioned by their capture and preservation. Shakespeare says, "The poor beetle that we tread upon, in corporeal sufferance feels a pang as great as when a giant dies"—which shows that he did not understand the anatomy of insects. "Minute dissections and the closest anatomical examinations have proved that, though insects are possessed of nerves, they have no well-defined organs representing the brain, the seat of concentrated feeling, where all the nervous connections meet. They have, instead, a chain of ganglia or bundles of nerve-substance, from each of which nerves branch out to contiguous parts, so that the sensations are not all carried to one grand central focus of acute sensibility as with us; but form as it were separate systems, any one of which might be destroyed without disturbing the sensation of the others." It is well known that large moths, found asleep in the day-time, may be pinned to the trunks of trees without suffering pain enough to awaken them, and, only at the approach of twilight, do they seek to free themselves from what they doubtless consider an inconvenient situation. It is related that Mr. Haworth, the well-known English entomologist, being in a garden with a friend who firmly believed in the acute susceptibility of insects, struck down a large dragon-fly, and, in so doing, accidentally severed its long abdomen from the rest of its body. The mutilated insect, after this misfortune, felt so little inconvenience or loss of appetite that it greedily devoured two small flies. Mr. Haworth then contrived to form a false abdomen, to create such a balance to the rest of the body as would enable it to fly; after which, it devoured another fly, and on being set at liberty, flew away with the greatest glee, as if it had received no injury. But all dispute upon this point should be ended by the entomologist's simple expedient of dipping his pin in prussic acid before piercing the insect, so that the effect is instantaneous.

—— Sir Charles Bell, upon looking over a biographical sketch of himself, made the following marginal comment on that part of it which spoke of his education: "Nonsense! I received no education but from my mother; neither reading, writing, ciphering, nor anything else. My education was the example set by my brothers. There was, in all the members of my family, a reliance on self—a true independence; and, by imitation, I obtained it. People prate about education, and put out of sight example, which is all in all."

—— A teacher in London, on being asked what moral education or training he gave to his scholars—what he did, for instance, when he detected a child in a lie—his answer was this: "I consider all moral education to be a humbug. Nature teaches children to lie. If one of my boys lies, I set him to write some such copy as this: 'Lying is a base and infamous offense'; I make him write a quire of paper over with this copy, and he knows very well that, if he does not bring it to me in a good condition, he will get a flogging."

—— Xanthus, the historian, says that a man killed by a dragon will be restored to life by an herb which he calls *balin.* Democritus asserted and Theophrastus believed that there was an herb at the touch of which the wedge the woodman had driven into a tree would leap out again.

—— The cautious and conservative old French *savant* Quatrefages says the more he reflects, the more he is convinced that man and animals think and reason in virtue of a faculty that is common to both, and which is only far more developed in the former than in the latter. He is very certain that when a cat is trying to catch sparrows on level ground, and creeps along the hollows, availing herself of every tuft of grass, however small, she knows what she is about just as well as the hunter who glides in a crouching attitude from one bush to another. He illustrates dog capacity as follows: "I once had a mastiff of pure breed, and which had attained its full size, remaining, however, very *young in character*. We were very good friends, and often played together. As soon as ever I assumed an attitude of defense before him, he would leap upon me with every appearance of fury, seizing in his mouth the arm which I had used as a shield. He might have marked my arm deeply at the first onset, but he never pressed it in a manner that could inflict the slightest pain. I often seized him by his lower jaw with my hand, but he never used his teeth so as to bite me; and yet, the next moment, the same teeth would indent a piece of wood I tried to tear away from them. This animal evidently knew what it was doing when it feigned the passion precisely *opposite* to that which it really felt; when, even in the excitement of play, it retained sufficient mastery over its movements to avoid hurting me. In reality it *played a part in a comedy*, and we can not act without being conscious of it."

—— Sydney Smith exhorts against *over-caution*. He says: "A great deal of talent is lost to the world for want of a little courage. Every day sends to their graves men who have remained obscure because of timidity. The fact is that, in order to do anything in this world worth doing, we must not stand shivering on the brink and thinking of the cold and danger; but jump in and scramble through as well as we can. It will not do to be perpetually calculating risks, and adjusting nice chances. It did all very well before the flood, when a man could consult his friends upon an intended publication for a hundred and fifty years, and then live to see its success for six or seven centuries afterward. But at present, a man waits, and doubts, and hesitates, and consults his father, brother, cousin, friends, till one fine day he finds that he is sixty-five years of age. There is so little time for our squeamishness that it is no bad rule to preach up the necessity of a little violence done to the feelings and of efforts made in defiance of strict and sober calculation."

—— The stories of Jonah and Methuselah are—but we should not complain; the faith of an orthodox Brahman is subjected to still severer tests. The sacred authority of the Sama-Veda vouches for the fact that Prince Yudirishi lived 2,300 and his rival Alerka 4,650 years. That is, however, a mere trifle, for a successor of the last-named potentate lived just 66,000 years; and the reader has hardly recovered his breath, when the next chapter informs him that King Yakoyesha lived 2,260,000 years and five months.—("Asiatic Researches," vol. ix, p. 305; compare Buckle's "History of Civilization," vol. i, p. 52.)

—— Truly *Heroic Cures* have somehow gone out of fashion. Dr. Hunt, writing in "Lippincott's Magazine," says that Paracelsus cured a leper by keeping him sixty hours in a bath of hot mud (Schrodt's "Analekten," vol. i, p. 106); and when medicine failed to relieve the chronic headaches of Count Philip, of Nassau, his surgeon trepanned his cranium *twenty-seven times*, and made him sign a certificate to that effect.

CORRESPONDENCE.

THE SCIENTIFIC EXPLORATION OF MAMMOTH CAVE.

Messrs. Editors.

IT is due to the trustees of Mammoth Cave to state that, while guarding their property rights, they have uniformly encouraged scientific investigation. Certain maps may have been modified and others suppressed; but, on the other hand, it should be noted that Manager Klett, with authority from the trustees, let me exhibit before the American Association the results of his own accurate survey of the cave, which it is his intention to publish when it is completed, in a form that can be depended on for all scientific ends. He laid no restraint on the members of the Association who visited the cave, at the close of the Cincinnati meeting, but allowed them to use barometers, pedometers, and other instruments. I regarded his request as reasonable that I should not give the *scale* on which his map is drawn, nor my own *table of distances*. The dimensions of domes, pits, and several large chambers were given, and other particulars of interest, that could not have been obtained but for the liberal aid of the manager.

Let me add, as to the temperature of the cave, that the maximum is 56° Fahr., the minimum 52½°, and the annual average 53°. The latter may also be taken as the mean temperature of the earth's crust in the locality of the cave, namely, latitude 37° 14′ 5″; longitude west from Washington, 9° 4′; and at an elevation of about five hundred feet above the level of the sea.

Please make the above corrections in your very gratifying report of my remarks before the American Association, and oblige,

Yours, respectfully,

H. C. Hovey.

New Haven, Connecticut, *December* 1, 1881.

[It is proper to add that, in making up our notices of the papers read at the last meeting of the American Association, we had to depend largely upon the reports of the proceedings in the daily papers, which are often imperfect in many points, and can not always be relied upon as correctly representing the author's meaning.—Editor.]

A CORRECTION.

Messrs. Editors.

In the December number of the "Monthly" I have coupled the names of Torel and Dana as believing that Greenland was the source of the American ice-sheets. If I had read Professor Dana's remarks more carefully, I should have discovered that he pronounced this view "absurd." Furthermore, in referring to the Canadian highlands as the starting-point of this ice, the early view of the same author was mentioned, but not the later one. Since 1873, Professor Dana has taught that the ice probably flowed from the Canadian (Laurentian) highlands across the St. Lawrence Valley into New England over the higher mountains, upon a lower over a higher level to the sea; and the motion was occasioned in great measure by the enormous ice accumulations of the north overflowing southerly. I regret exceedingly the misstatements.

C. H. Hitchcock.

Hanover, New Hampshire, *December* 7, 1881.

A TYPOGRAPHICAL ERROR.

Messrs. Editors.

On page 267 of the December number, at the bottom of the first column,

Boston	164	0
Cincinnati	0	155

should read—

Boston	164	—
Cincinnati	—	155

The Cincinnati members present at Boston were counted from Ohio, the Boston members at Cincinnati from Massachusetts.

E.

November 24, 1881.

AN ARCHÆOLOGICAL QUESTION.

Messrs. Editors.

The following inscribed objects have been found within the limits of the United States:

1. The Grace Creek stone, West Virginia.
2. The Pemberton axe, Pemberton, New Jersey.
3. The Davenport slates, Davenport, Iowa.
4. The Piqua tablets, Piqua, Ohio.

It is evident that, if they are authentic, they are of immensely more importance than implements or pottery.

If they are "archæological frauds," gentlemen who follow that branch of science should lend their aid to convict them.

Under these circumstances, and having devoted as much time to the study of this particular branch as any person with whom I am acquainted, I take the liberty, in the interest of knowledge, to ask an expression

of opinion in regard to any or all of these objects from the following gentlemen: Professor Putnam, of the Peabody Museum; Professor Rau, of the Smithsonian Institution; Colonel Mallery, of the American Association for the Advancement of Science, and chairman of its Anthropological Section; and Judge Henderson, of the same section.

I have no hesitation in saying for myself that I think there is absolute certainty of the genuineness of these objects; and I can hardly doubt that these gentlemen will avail themselves of an opportunity to confirm my impression, or disabuse me of my error.

I am, sir, your obedient servant,
WILLIAM S. BEEBE,
Brevet-Major U. S. Army.

BROOKLYN, *December* 6, 1881.

EDITOR'S TABLE.

THE CHARGES AGAINST "THE POPULAR SCIENCE MONTHLY."

THE publishers of this magazine, having declined any longer to issue the "North American Review," because of its recent articles from the pen of Colonel Ingersoll, have been charged with inconsistency on the ground that, in respect to the matter objected to, the periodical they retain is as bad as the one they have dismissed. A writer in the "Evening Post" says: "I would like to know how and where Messrs. Appleton & Co. draw the line which makes the same opinions detestable in the 'North American Review,' which are endured in 'The Popular Science Monthly.' The editorial views of the latter publication are certainly as pronounced in their atheistical tendencies as anything Colonel Ingersoll ever uttered, and for a long period of years this journal has published everything of interest written by pronounced atheists, and excluded everything which has appeared of merit on the other side. The papers of Herbert Spencer, and others of his class, have been presented, but such writers as the Duke of Argyll have never been permitted to offer their views."

This accusation against "The Popular Science Monthly," that it is a teacher of atheism, has been made before, and met before; but, as the present circumstances give it point and revive its interest, we propose now to reconsider it, and again see what it amounts to. We shall thereby be enabled to judge whether the two magazines really teach the "same opinions" upon this subject, as the writer in the "Post" affirms.

The paragraph just quoted would have been more satisfactory if it had been more explicit; for here, if anywhere, clear distinctions are demanded. What does the writer mean by "pronounced atheistical tendencies" and "pronounced atheists"? Does he mean that their atheism is avowed or imputed; that they pronounce themselves atheists or are so pronounced by others? These are not only different things, but the distinction is here very material; so that it becomes necessary, before we can find out who are truly atheists, to have the test by which they are known. Because a man is called an atheist, are we to hold that he is therefore, in fact, an atheist? We were once accosted by an inquisitive Irishman thus: "D'ye b'lieve in the mother o' God?" "No." "Be gorry, y'er an atheist; I wouldn't be in y'er boots for twenty pound." Was that a satisfactory basis of classification? Professor Huxley had a cook who got on a drunken spree, and made such a row in the house that the police were called. As she was hustled through the yard, she sent back a blast, of which all that could be understood was an emphatic "damn athish!" Is Professor Huxley, therefore, to be ranked as a "pronounced atheist"? But, if a drunken cook is not an authority on this point, is a

sober bigot any better? It is the common and very foolish trick of religious partisans to stigmatize those who differ from them in their views of Deity as atheists. Each one identifies God with his own scheme of belief, and, if that scheme is objected to, the objector is denounced as a denier of God. Particularly where the conception of God is low, gross, and materialistic, is every higher view charged with atheism. There is, however, no honest difficulty here. We have exactly the same means of knowing atheists that we have of knowing Baptists or Buddhists, that is, by what they profess and teach. We should call Bradlaugh a "pronounced atheist," because we have heard him say that he is the only man who ever ran for Parliament distinctly as an atheist. He has, besides, a large following in open agreement with him, and who may, therefore, be properly called atheists. A "pronounced atheist," in short, must simply be one who pronounces himself an atheist.

And now, having found that atheists are those who avow a certain belief, it is desirable to note distinctly what that belief is. Atheism, says Webster, "is the denial of the existence of a God." But the term God has many significations, and is variously defined. We take the highest definition given by Webster, "the Supreme Being; the Eternal and Infinite Spirit." A pronounced atheist, therefore, is one who professes to deny the existence of "the Supreme Being; the Eternal and Infinite Spirit."

The writer in the "Post" declares that "The Popular Science Monthly" "has published everything of interest written by 'pronounced atheists,' and excluded everything that appeared of merit on the other side." The other side of what? Why, the advocacy of atheism, of course! That is, "for a long period of years" this magazine has been given over to the work of teaching the doctrine of the non-existence of "the Eternal and Infinite Spirit." This statement is not true; it has not a vestige of truth in it; it is wholly and absolutely false. This is one of the charges that calls for proof, and happily the writer has given his proof. It is this and nothing else, that "the papers of Herbert Spencer and others of his class" have appeared in "The Popular Science Monthly." That any such papers really have the character charged, there is not the slightest attempt at proof.

But Herbert Spencer is not an atheist, and never has been. He has never declared his belief in atheism, and he is a man who expresses his opinions very freely and with but little regard for their popularity. He has been called an atheist, but that, as we have seen, will not do. If we had space we could fill pages with admissions on the part of all his ablest theological critics that he is not an atheist. We challenge the "Post" writer to produce a single passage in all his writings, in the "Monthly" or out, either avowing or defending atheism. On the contrary, he has labored with all the power of his genius to prove that atheism as a theory of the universe (which it professes to be) is baseless and indefensible. And more than this, no man of the present age has reasoned out the foundations of man's belief in the existence of the "Infinite and Eternal Spirit" with such a depth of analysis and logical force as Herbert Spencer. He has sought to show that the "Infinite and Eternal Spirit," of which all the phenomena of the universe are but the manifestations, is the most absolute of all realities.

And still more than this is true. Mr. Spencer has gone beyond the theologians in their own line, and has rescued them from the consequences of their own logic. Every intelligent person knows that there has been a great progress in the religious ideas of man-

kind; and in nothing has that progress been so clearly evinced as in the gradual elevation of man's conceptions of the character of the deity he worships. During all the primitive ages, religion was idolatry, and still is so, almost all over the world. But with growing intelligence there slowly arises a higher idea of the Divine Nature. Polytheism passes into monotheism, and the gross, limited, anthropomorphic idea of God gives place to the loftier ideal of an "Infinite and Eternal Spirit." In this clearing away of limitations how far was the work to go, and what to be finally left? The theologians had been driving destructive criticism to its last extreme, with but little apparent care for the consequences. There grew up a vigorous ecclesiastical agnosticism, asserted even by the fathers of the Church. Clemens Alexandrinus (A. D. 200) says of God, "We know not what he is, but only what he is not." Cyril of Jerusalem (A. D. 350) affirms, "To know God is beyond man's power." St. Augustine (A. D. 400) observes, "Rare is the mind that in speaking of God knows what it means." John of Damascus (A. D. 800) declares, "What is the substance of God or how he exists in all things, we are agnostics, and can not say a word." Duns Scotus (A. D. 1300) remarks: "Is God accessible to our reason? I hold that he is not." This tendency to remove the Divine Nature beyond the grasp of reason, and to hold that "a God understood is no God at all," has grown in strength in modern times, and reached its full expression in the theological philosophy of Hamilton and Mansell, which landed inquiry upon this subject in blank negation. Finding that the "Infinite and Eternal Spirit" transcended and baffled all reason, they assumed that reason brings us to an infinite nothing, so that we have no alternative but to give up the idea of an Infinite Power, or fall back upon faith. Mr. Spencer strenuously resisted this conclusion. He maintained that the most inexorable logic brings us not to an Infinite Nothing, but to an Infinite Something; and, although this "Eternal Spirit" transcends the reach of reason, and is "past finding out," yet that its existence is the profoundest of all verities. Where the case broke down in the hands of the theological analysts, he insists that it is demonstrably the strongest. Whether he proves his case is not here the question; we only declare that such is his position, which is in dead antagonism to atheism. But it is proper to say that many of his able opponents acknowledge that Mr. Spencer has contributed new and powerful arguments for the existence of an "Infinite and Eternal Spirit." In the presence of these facts, well known to all who care to know, what shall we say of the veracity, the honor, or even the decency, of those who flippantly reiterate this groundless charge?

And it is important here still further to observe that Mr. Spencer is not a denier or antagonist of religion. He holds it to be a reality, a great truth; in short, nothing less than an essential and indestructible element of human nature. The religious institutions of the world, he maintains, represent a genuine and universal feeling in the race just as really as any other institutions. With the accessory superstitions which in all ages of ignorance have overgrown and perverted the religious sentiment, he is, of course, not in agreement; and he maintains that the confounding of these with the religious sentiment itself, is a mischievous mistake of religionists and anti-religionists alike. And he furthermore holds that science, in clearing away these superstitions, is bringing us ever nearer to the underlying truth, and is, therefore, doing the highest religious work. And, besides, in all his discussions of religious subjects, though bold, he is reverent, respectful to sincerity, tolerant of honest prejudice, and never wantonly irritat-

ing in the treatment of what he regards as religious errors.

A line is to be here drawn, clear and sharp, separating this mode of regarding religion from that which proclaims it to be a sham, an imposture, and a mere invention of priestcraft to cheat credulous people. Between him who believes that religion is a great and sacred reality, and him who denounces it root and branch, as a delusion originating in fraud and knavery, there can be no common ground. These are not the "same opinions," but diametrically opposite opinions. A criticism of religious errors, however trenchant it may be, if it gives the subject sincere and respectful consideration, is as different as any two things can be, from a spiteful, ruthless, and exasperating assault upon the religious sentiment of the community. And when these opinions are published for no other reason than to startle and shock the public by their audacity, and for no other than a sordid purpose, the case is still further aggravated. "The Popular Science Monthly" has left others to make what they might out of this policy.

The writer in the "Post" complains that we have not published the views of such men as the Duke of Argyll, to which we reply: 1. That we should have been glad to publish the Duke of Argyll's articles, but had no room for them. 2. That we started a supplement to make more room, and *did* publish the views of the Duke of Argyll. 3. That the papers of his Grace have been very widely reprinted in other channels, so that the public has experienced no inconvenience from the want of them. The "Monthly," we must remember, was established, not for the display of polemical pugilism, but for the serious purpose of placing before American readers the most important results of scientific thought as presented by its ablest expositors. So far, indeed, has it been from seeking sensational papers, that its main purpose was to publish a class of valuable scientific articles, which, because they are too heavy or will not pay, or conflict with public prejudices, were systematically excluded from our current magazines. While striving to make our pages as varied and attractive as possible, we have not sacrificed the character of the magazine to promote its pecuniary success. We have maintained a steady course, our last issue is strictly in the line of the first, and all the wide approbation that has been accorded us from the beginning is as applicable now as it ever was.

The "New York Observer," in commenting upon this subject, agrees with the writer in the "Post" that the "Monthly" is as bad as the "Review," if not worse, and it very plainly says: "We with thousands hope sincerely that the commendable course taken by the eminent publishers, in kicking the 'Review' out of their premises, will be followed in regard to the 'Monthly.' Or, what would be better still, let us hope the 'Monthly' will omit its atheistic teachings, and become such an organ of science as the great body of intelligent people will admit with confidence into their homes."

We have exploded the charge of the "Post" writer, here repeated, because he gave us his evidence, and we had something tangible to deal with. But the "Observer" scents atheism in everything scientific, and, if we began to expurgate in accordance with its notions, we should have to expunge the whole "Monthly." For does not the "Observer" hold evolution to be atheistic? And what would "The Popular Science Monthly" be, *minus* evolution? It is the new dispensation of scientific thought, cropping out everywhere, antiquating old views, affording new explanations, reorganizing knowledge, and guiding the researches of scientific men in every field of investigation. Those who do business on old opinions are in a great state of perturbation and

distress about it. Some are for "giving in," some are for patching up compromises, and some for "fighting it out." Meanwhile the tide is carrying everything before it, and the confusion of the unready waxes grotesque. The foreign periodicals arrive monthly loaded with evolutionary discussions; and in the last "Contemporary Review" Calderwood, of Edinburgh, announces that even Hegelianism is but "dialectical evolution."

The "Observer" suggests that we make such a periodical "as the great body of intelligent people will admit with confidence to their homes." This sounds well, but what is it in a little plainer English? "Divest your 'Monthly' of every feature that can be objectionable to those who care a good deal more for theological than for scientific teachings, and who have a horror of all science as tending to infidelity." We should not be permitted to say a word of the progress of scientific thought, because hardly a step is taken anywhere that somebody with a dogma in that direction does not cry, "Halt, you destroyer of religion!" We indulge in no exaggeration. The "Observer" is authority here, and right above the article in which it recommends that the "Monthly" be kicked off the premises, we read, "SCIENCE FORGES WEAPONS CONSTANTLY TO DESTROY THE FAITH." What kind of a scientific magazine would that be which should be suited to the state of mind of the dismal creatures who take such a view of science as this? We should rather take the "Observer's" alternative, and be kicked into the street, than to edit such a periodical.

The "Observer" accuses science of "forging weapons to destroy the faith"; but need we remind it that science destroys nothing but ignorance and error? Only where faith is the enemy of truth can science be the enemy of faith. Science is the best friend of faith, for only when it has destroyed all it may, can faith have any "abiding foundation." We are afraid that, when the "Observer" invokes the publishers' boot as a censor of science, it betrays some want of confidence in its own foundation. What shall we say of the security of a religious edifice built upon the basis of literal Old Testament history? But in the very next column to the article we are noticing, it is laid down: "A DENIAL OF THE LITERAL VERITY OF THE OLD TESTAMENT HISTORY IS THE FIRST STEP IN MODERN INFIDELITY."

No more complete or more mischievous mistake can be committed than to impute to the scientists of this age any hostility to religion as the motive of their labors. That the course of inquiry often conflicts with cherished tenets is undoubtedly true, and it is a painful fact; but to charge scientific men with any intention of inflicting this pain, or to make them responsible for it, is wholly unjust. The world has never seen in all its history a class of men more noble in purpose, more fair-minded, more candid, tolerant, or considerate, than the class of men who, in all countries, though with a common spirit, have devoted themselves to the truth—as it is in science. They have done their work with a single-mindedness, a freedom from partisan and sectarian passion, and an openness and uprightness of purpose, that find no parallel in any other great group of men engaged in the advancement of a common interest. These men are entitled to stand first in the respect and confidence of the community; and to accuse them of being animated in their study of nature by a desire to destroy religion, or to wound the feelings of religious people, is thoroughly unjustifiable.

"The Popular Science Monthly" is a record of the scientific activity of the age for the last ten years, and it reflects the breadth, the independence, and the catholicity of thought that distinguish

the scientific men of our time. There may have been many things said in it which people with a formulated faith find objectionable; but they are the results of honest and earnest thought, and the incidents of legitimate discussion, and must, therefore, be tolerated. Science can not work under the dictation of those interested to restrain it. Are men who make the supreme purpose of their lives the understanding of nature, to stop research into the laws of life, the genesis of species, the antiquity of man, the functions of the brain, the laws of social growth, or the natural history of superstitions, because there are many who, without ever studying these subjects, have views in relation to them which they do not wish disturbed? It is impossible. The great modern movement of the human mind which we call science is a part of evolving nature, and we have no liberty to do anything but represent it as faithfully as we are able.

ANNOUNCEMENT.

THE next volume of the "International Scientific Series," to be issued early in January, will be a work of such exceptional importance to various classes of thinkers, that we deem it proper to call especial attention to it in this place. It will be entitled "The Concepts and Theories of Modern Physics," and is written by Judge J. B. Stallo, of Cincinnati, author of a work, published many years ago, on "The Philosophy of Nature."

The book is a critical inquiry into the validity and sufficiency of what may be called our present scientific foundations. The author holds that the generally accepted hypothesis of the atomo-mechanical constitution of nature, and the various modern theories that grow out of it, are deeply tainted with metaphysical error; and his purpose has been to draw the line between legitimate science and illegitimate speculation. There is now no subject that more urgently needs to be cleared up than this.

The author says of his work: "Its tendency is throughout to eliminate from science its latent metaphysical elements, to foster and not to repress the spirit of experimental investigation, and to accredit instead of discrediting the great endeavor of scientific research to gain a sure foothold on solid empirical ground, where the real data of experience may be reduced without ontological prepossessions. An attentive perusal of these pages will make it clear, I think, that this endeavor is continually thwarted by the insidious intrusion into the meditations of the man of science of the old metaphysical spirit. This fact having been established, it was incumbent on me to ascertain, if possible, its causes and, within the narrow limits at my command, to develop its consequences. . . . What is here presented is not, of course, a new theory of the universe, or a novel system of philosophy. I have undertaken, not to solve all or any of the problems of cognition, but simply to show that some of them are in need of being stated anew so as to be rationalized, if not deepened."

Judge Stallo is a master of the field of modern physics, and the original views of his book are presented with great clearness and force. This volume will be one of the very ablest of the "International Scientific Series."

LITERARY NOTICES.

ARTIFICIAL ANÆSTHESIA AND ANÆSTHETICS. By HENRY M. LYMAN, A. M., M. D., Professor of Physiology and of Diseases of the Nervous System in Rush Medical College, Chicago, etc. New York: William Wood & Co. 1881. 8vo. Pp. vii–338.

"The most ancient record of the race," says Professor Lyman, "introduces the hero of the flood plunged in a deep and scandalous sleep, under the influence of wine which

he had prepared." From the time of Noah to that of Long, Morton, Wells, and Warren, the history of anæsthesia is concisely summarized in the first chapter of the present work; a history terminating in the final success of the search, which man has been making from the remotest antiquity, for the means of arresting or annihilating physical pain. "The venerable Nestor came to the relief of the wounded Machaon with a medicated poultice composed of cheese, onions, and meal, mixed with the wine of Prâmnos. . . . Some preparation of opium or of Indian-hemp it may have been with which, after the ten years' siege was ended, beautiful Helen drove away sad memories from the minds of her husband and his friends, making them drink of wine into which she cast a drug presented to her by the Egyptian princess Polydamna. Most potent this same nepenthe must have been, for we are told (Odyssey, iv, 220) that it delivered men from grief and wrath, and caused oblivion of every ill." Some of the ancient soporifics are well-known to us, as opium, Indian-hemp, mandragora; and probably they employed carbonic-acid gas also. Mandragora was the favorite among the Greeks; infused in wine, it was known as *morion*. "Apuleius states that half an ounce of this would render a person insensible even to the pain of an amputation. Dioscorides taught that the sleep thus produced might continue four hours or more; hence, no doubt, various legends which were by Shakespeare interwoven into the story of Juliet. The wine mingled with myrrh which was offered, according to the custom of the kind-hearted Jewish women of the day, to Jesus on the cross, was unquestionably this same mandragora-wine." During the time of Dante the following soporific, Hugo di Lucca's prescription, was used for patients about to undergo operations: they were caused "to breathe the vapors given off from a sponge moistened with warm water, after it had been thoroughly steeped in a decoction of opium, deadly nightshade, hyoscyamus, mandragora, hemlock, ivy, and lettuce. Sponges thus medicated were to be dried in the sunshine, and stored for use as occasion might require.

During the eighteenth century trials were made for anæsthetic purposes of hypnotism, freezing mixtures, intoxication, and pressure upon the trunks of the principal nerves. All these methods were, of course, unsatisfactory; chemical science, indeed, was not yet sufficiently advanced for the more recent discoveries. In 1799 Sir Humphry Davy discovered the intoxicating effects of nitrous oxide gas. Sulphuric ether was employed by Dr. Pearson, of Birmingham, in 1785, as a means of relief for spasmodic asthma; and in 1805 by Dr. Warren, of Boston, in the later stages of consumption. It was first used to produce insensibility to pain during a surgical operation by Dr. W. C. Long, of Jefferson, Georgia, in 1842. This great event, says Professor Lyman, "was thus simply recorded by Dr. Long in his ledger: 'James Venable, 1842. Ether and excising tumor, $2.00.' In the same year, William T. G. Morton employed sulphuric ether in tooth-pulling. Then came nitrous oxide or laughing-gas, used in tooth-pulling in 1844, by Horace Wells. In October, 1846, Morton made the surgical use of ether known to the world. "From that date the success of anæsthesia in surgery was placed beyond all doubt." In 1847 the eminent physiologist, Flourens, discovered the anæsthetic properties of chloroform, and it came rapidly into use. These are the facts over which the endless controversies of the rival claimants have been raised—controversies which this is not the place to follow.

From the history of anæsthesia Professor Lyman passes to its physiology and its phenomena; discussing the various procedures by which it is produced, whether generally or locally, the statistics and the treatment of the accidents resulting from it, the medico-legal relations of the subject, and the various classes of cases in which the anæsthetic substances may be employed. The larger part of his book is taken up by a detailed examination of the numerous substances classifiable under his title, no less than forty-seven being enumerated and described, besides which other methods than the posological, as anæsthesia by electricity, by rapid respiration, and by cold, are studied. A feature of the work is the citation of remarkable illustrative cases. The experience of Dr. J. Marion Sims (p. 58), in a case of apparent death from chloroform, is one of those dramatic recitals which give

irresistible interest to a purely scientific discussion.

Professor Lyman has made an excellent compend of what is known upon the subject of anæsthetics and their use. The book covers the history, theory, and practice of the topics discussed; and not the least merit of the treatment is its attractive style. Dr. Lyman has not availed himself of the ancient prerogative of medical science, to be dull. The work of a learned physiologist and practitioner, it is properly classed by its publishers among their standard medical authors.

A REPORT ON THE TEACHING OF CHEMISTRY AND PHYSICS IN THE UNITED STATES. By FRANK WIGGLESWORTH CLARKE, S. B., Professor of Chemistry and Physics in the University of Cincinnati. Washington: Government Printing-Office. Pp. 219.

THIS is No. 6 of the "Circulars of Information" of the Bureau of Education for 1880. It embraces the substance of the replies to a schedule of questions which the Commissioner of Education sent out in 1878 to the schools of the country relative to the teaching of physics and chemistry, and covering the items of the courses of study, the text-books used, the value of apparatus, the library facilities and policy, the character of examinations, and the cultivation of original research. These replies were referred to Professor Clarke to digest and collate. His report, the purpose of which, in accordance with the design of the Commissioner of Education is, first, to state the facts, and second, to point out defects and remedies, includes a specific account of the instruction given in all those schools, public or private, of whatever grade, from which sufficient information to form the basis of such an account was received. In the prefatory parts of the descriptive chapters assigned to the several classes of schools, the author offers free general criticisms of the methods, and his own views of their defects, and the improvements of which they are susceptible, in observations which are of much value and interest. Passing the question of the desirability of teaching the sciences in primary and intermediate schools as an open one, the expediency of teaching chemistry and physics in secondary schools is regarded as generally admitted. Not less than half a year should be given to each, and "a year can usually be given without difficulty." Instruction should be general rather than special, and the text-book should be supplemented by the knowledge of the teacher, which ought to be enough "to render him in a measure independent of text-books." Normal schools by the theory of their existence ought to recognize the fact that their students may be called upon to teach chemistry and physics, and endeavor to train them intelligently in methods of instruction, and a few of them do so. As to the colleges, in most cases they teach chemistry and physics to the same extent as the preparatory schools, and in essentially the same way. "The conclusion is obvious that the colleges ought to do higher work. . . . The present repetition or duplication of studies is clearly wasteful, and ought to be abolished." With a few honorable exceptions, the colleges which are doing the best work in chemistry and physics are those which have adopted the elective system. The system of instruction in medical and related schools needs, as a rule, much improvement, but, "fortunately, a healthier state of affairs is rapidly developing." Insufficient attention to laboratory work or the neglect of it is a chief defect in a large proportion of the schools. Laboratory practice in physics is necessarily limited in preparatory schools, but a greater variety is attainable in chemistry, in numerous simple and ordinary experiments, which are cheap, and ought to be sought out and used. In the normal schools the future teacher may be taught the art of getting along with make-shifts, and to construct simple apparatus out of the commonest materials.

ILLUSTRATIONS OF THE EARTH'S SURFACE. GLACIERS. By NATHANIEL SOUTHGATE SHALER, Professor of Paleontology, and WILLIAM MORRIS DAVIS, Instructor in Geology, in Harvard University. Boston: James R. Osgood & Co. Pp. 196, with 25 Plates and Descriptive Texts. Price, $10.

THIS work is designed to be one of a series of volumes of "Illustrations of the Earth's Surface," to be entitled severally "Glaciers," "Mountains," "Volcanoes and

Earthquakes," "Lakes and Plains," "Rivers and Valleys," "The Sea and its Shores," "Structure of Rocks," and the "Effects of Life." The purpose of the series is to remedy, as far as can practically be done by using the best attainable pictorial illustrations, the difficulties besetting the teaching of geology, which arise from the remoteness of the facts on which the teaching must rest, and the present impossibility of the pupil's going and observing them for himself. Hence, photographs are chosen, when they can be got, on a scale represented by a page as large as that of the current sixteen-page newspaper. The present work was originally designed merely to furnish a collection of photographs of glaciers, along with descriptions that might serve to call the attention of the student to the most noteworthy features in the objects represented. The photographs given are bright and spirited, far superior to anything found in books accessible to students, and the descriptions, lucid and satisfactory; but it was found by the projectors of the work that this would not be enough. The descriptions needed to be supplemented by a connected sketch of the more important part of the subject-matter. The author of the sketch, Professor Shaler, was compelled by the contract with the publishers to prepare it "with far greater haste than was proper in such a work," a fact which he and the publishers should not have tolerated, for the public have a right in such a work to the best preparation possible; but he has given a comprehensive and excellent review of the whole subject of glaciers and glacial action. The sketch embraces chapters on existing glaciers and their distribution, the distribution of ancient glaciers, "The Work of the Glacial Time," "The Origin and Nature of Glacial Periods," "Ancient Glacial Periods," "The Climatal Conditions of Glacial Periods," "The Effect of Glaciers on the Altitude of the Lands," "The Effect of Glaciation on the Life of the Earth," "Relation of Glaciation to the History of Man," "The Movement of Glaciers," "Certain Effects of Glaciers," a glossary, and a bibliography of the subject. The plates are mostly illustrative of Swiss glaciers, and are arranged so as to show—1. A general view of glacial form; 2. Details of structures from greater to less altitudes; and, 3. Effects of glacial action. A few are added from Norway, the Himalayas, and Colorado, with illustrations of glacial and weather-marks on rocks, and maps of the distribution of glaciers, ancient and modern.

ADAMS'S SYNCHRONOLOGICAL CHART OF UNIVERSAL HISTORY. Price, $15. New York: Colby & Co., No. 5 Union Square.

THE superiority of the eye as an inlet of knowledge, over all the other senses, is generally admitted, though it is not generally half appreciated. If people will examine the contents of their minds, they will find that far the greatest portion of them are visual acquisitions. It would be a very moderate estimate to say that nine tenths of our ideas are got through the help of the eye. Visual impressions are, besides, of a higher grade than those of the other senses. They are sharper, clearer, and all their relations are more definite. Then, again, they are more adherent than any other impressions—that is, they stick in the mind and are easiest remembered. Visual ideas are also the most perfect—that is, all the complexities and fine diversities of nature are reproduced in thought through the eye. At a glance a whole landscape becomes the property of the mind. We think in pictures; and the highest faculty of the intellect is that which pieces together old pictures and creates new ones. The eye is the only sense that gives us images; and how far imagining goes in mental processes is shown by the exalted office of the *imagination*—the image-working faculty of the mind.

From these facts we are led to perceive the transcendent importance of the eye in education. Acquisitions made by light are of course the most lucid. They are not only the most vivid, but the easiest understood and the longest retained. Hence, wherever a subject can be illustrated by maps, charts, and pictorial diagrams, there is an enormous gain in the mental economics of learning.

History is a subject which in its leading facts is capable of treatment by the visual method, as Adams's chart strikingly illustrates. The events of the world have all occurred in a double relation of coexistence and of sequence. Many trains of occur-

rences go on together or synchronously; and in each line there is a chain of succession in the parts, which proceed in the order of cause and effect. Nations and empires run their careers as it were side by side, rising, flourishing, decaying, and giving place to others; while each nation has its epochal changes of dynasty, revolution, or conquest. These relations of events are capable of being mapped, and they are so skillfully represented in Adams's chart that we get, as it were, a bird's-eye view of the procession of great terrestrial affairs. The chart is twenty-five feet long by three deep, and mounted on rollers, so that, if there is not room to fully display it, its parts may be brought successively into view. Vertical lines show contemporaneous events, and horizontal bars of color represent succession, the stream of time, and the progress of civilization. The march of fifty-nine centuries is delineated, and the great transactions of the world—national, civil, military, religious, maritime, architectural, inventive, and literary—with the advent of great men, are all pictorially represented in their time-relations, so that an accurate outline of history may be rapidly and easily acquired.

It would take a book to describe the chart, and so we shall not attempt it, but will only say that for introducing the young to the study of history, and for common reference in reading general history, it will have great usefulness. Much pains has been bestowed upon its preparation, and a good deal of information crowded into limited space. The Hebrew cosmology and Usher's chronology are adopted, and more supernatural events are located than science might perhaps approve; but this does not impair the general utility of the work, which is conformed, if not to the latest, at any rate to the prevailing, state of knowledge.

MEXICAN PAPER: AN ARTICLE OF TRIBUTE. Its Manufacture, Varieties, Employment, and Uses, compiled from Pictorial and Written Records. By PHILIPP J. VALENTINI, Ph. D. Worcester, Massachusetts: Charles Hamilton. Pp. 26.

AN interesting study of a single feature of ancient Mexican civilization. The painted records of the "Codex Mendoza" show that certain towns had to furnish enormous quantities of paper to the city of Mexico. The fact suggests an examination into the Nahuatl name for paper, and its occurrence in combination in the names of some towns, the symbols by which it is represented in the pictographs, the method of manufacturing it, and the uses that were made of it, which were very diversified. Especially were large quantities of paper employed on occasions of ceremonial and dress.

TENTH REPORT OF THE STATE ENTOMOLOGIST ON THE NOXIOUS AND BENEFICIAL INSECTS OF THE STATE OF ILLINOIS. Fifth Annual Report, by CYRUS THOMAS, Ph. D., State Entomologist. Springfield, Illinois: State Board of Agriculture. Pp. 244.

THE demand for the entomological reports is steadily increasing within and without the State, and even in Europe. In order to make the work as useful as possible to farmers, who most frequently meet the insects and can most readily recognize them as larvæ, predominance is given to descriptions of the larval state. The plan has been adopted of making a specialty each year of some particular class of insects. Thus Dr. Thomas's second report gave considerable space to the chinch-bug; his third report was devoted to plant-lice; the fourth report largely to the European cabbage-worm; and the present volume considers at some length the history and habits of the army-worm, with a view of arriving at the best practical remedy. It also gives a paper, by Dr. A. S. Packard, on the Hessian fly, and accounts of many other insects.

THE LANDA ALPHABET A SPANISH FABRICATION. By PHILIPP J. VALENTINI, Ph. D. Worcester, Massachusetts: Charles Hamilton. Pp. 35.

GENERALLY, the ancient Mexicans were supposed to have no alphabet, and their writing to be pictorial, but an alphabet ascribed by Bishop Diego Landa, of Yucatan, to the Maya people was regarded as an exception. The author advances the opinion that this was not a genuine alphabet, but was compiled by the bishop from selections of ideographs whose sounds most nearly approached the sounds of the letters, for the purpose of assisting the Yucatecans in learning their *pater noster*. In support of this position, an analysis of each character is presented.

BOTANY. Outlines of Morphology, Physiology, and Classification of Plants. By WILLIAM RAMSEY MCNAB, M. D., F. L. S., Professor of Botany, Royal College of Science for Ireland, Dublin. Specially revised for American Students, by CHARLES E. BESSEY, M. Sc., Ph. D., Professor of Botany in Iowa Agricultural College. New York: Henry Holt & Co. 1881. Pp. 400. Price, $1.10.

IT is claimed for the American revision of McNab's work that it is less technical than the foreign book, and has been completely adapted to American use by changes in the classification, and by the introduction of American examples. There has also been a considerable simplification of the text, an omission of some paragraphs and a use of smaller type in others, so as to bring the work into the compass of one volume. Besides, the book has been divided into chapters, sections, and numbered paragraphs. It is designed for "second or middle class schools," and aims to present the "study of plants as living things, rather than their bare analysis and classification."

In clearness, conciseness, and perfect adequacy of statement, the text of this school-book leaves nothing to be desired. It is well illustrated, and may be recommended as a valuable book for general readers. But we are a little puzzled about its place as a school-book. We do not understand what the editor means by "second or middle class schools." Is it the next grade above our primary schools? Is it meant as a first book to introduce children of say a dozen years to the study of plants. If it is designed for beginners in botany, we do not hesitate to pronounce the work a mistake. To begin this study with the minute structural elements of plants which are only discernible through the microscope, and with the lower microscopical forms of vegetation, is to put the difficult and complex before the plain and apparent. It can not be claimed that vegetable anatomy is a more important division of the science than organography; but it is certainly more requisite to the comprehension of vegetable physiology, or the plant considered as a "living being." It would seem that there existed in the mind of the American editor a kind of partisan feeling as regards the various departments of this science. He prefers the "study of plants as living beings," to what he terms their "bare analysis and classification," and so he offers us a school-book which is neither in accord with the true order of the science of botany nor with the unfolding faculties of the pupil.

Botany has to deal with plants in respect to their kinds as well as their functions. Professor Gray, who has had some experience of the contrary method, says that the study of botany naturally begins with the structural botany of flowering plants. In his recently published "Structural Botany" he omits, as far as possible, all reference to intimate structure, development, and function, leaving these subjects to be treated in the second part of his work, which has not yet appeared, and which is devoted to physiology.

That children should begin the study of botany with organography follows, not only from a consideration of the science as a whole, but is still more obvious when we regard the particular subjects dealt with in its various divisions. In organography, distinctive names are applied to the different organs of plants and their endless variations of form. A knowledge of these terms is indispensable to the botanist, and in childhood it is acquired with ease and pleasure. This botanical vocabulary enables the student to describe the objects of his study with precision and brevity, and in its acquisition and use he is forming the all-important habit of careful observation, and is getting knowledge at first-hand or by self-teaching. In fact there is not another subject in the whole range of the sciences so well suited to the training of the dominant faculties of children in the earlier grades of our public schools as is this department of botany, which is declared on high authority to be the natural beginning of the study.

SEEDLESS FRUITS. By E. LEWIS STURTEVANT, M. D., South Framingham, Massachusetts. Pp. 29.

NUMEROUS instances of plants in which such combinations occur are cited in support of the view that the abnormal development or richness of any part of a plant, as the pulp of a fine fruit, the root, or the tuber in case of the potato, is apt to be attended with deficiency, defectiveness, or entire absence of seeds.

A MEMOIR ON LOXOLOPHODON AND UINTATHERIUM, by HENRY F. OSBORN, Sc. D.; accompanied by a STRATIGRAPHICAL REPORT OF THE BRIDGER BEDS IN THE WASHAKIE BASIN, by JOHN BACH MCMASTER, C. E., Princeton, New Jersey. Pp. 54, with Four Plates, a Map, and a Profile.

BESIDES its ample collection of specimens for college instruction, the E. M. Museum of Geology and Archæology of Princeton College contains a large amount of material for more advanced study in the shape of fossils new to science, mainly collected by the college scientific expeditions of 1877 and 1878. The paleontologists and biologists connected with the museum have decided to place the results of their studies in a permanent and suitable form before the scientific public; and, in pursuance of this resolve, begin, with this pair of monographs, a series of memoirs, in quarto, of more mature researches, in addition to the bulletins of their current work which they have published since 1878. There are many persons not acquainted with the early history of the institution who might be glad to know the meaning of the initials E. M., in the name of the museum.

A SKETCH OF ANCIENT PHILOSOPHY, FROM THALES TO CICERO. By JOSEPH B. MAYOR, M. A., Professor of Moral Philosophy at King's College. New York: Macmillan & Co. Pp. 254. Price, 75 cents.

THE large divisions of this work are three, as follows: (A.) The Socratic Philosophy of Nature. (B.) Socrates to Aristotle —Philosophy of Nature and Man. (C.) Post-Aristotelian Philosophy of Man.

Under these divisions there is given an account of—1. The Ionic School; 2. The Italic School; 3. The Ionico-Italic School; 4. The Sophists; 5. Socrates; 6. The Cynics; 7. The Cyrenaics; 8. Plato; 9. Aristotle; 10. The Peripatetics; 11. The Skeptics; 12. The Old Academy; 13. The Skeptical Academy; 14. Stoicism; 15. Epicureanism; 16. Eclecticism; 17. Cicero.

As to the treatment, it is brief; but quite sufficient and most scholarly—so much so, indeed, as quite to unfit the book for general use. It abounds with Latin and Greek quotations that are not translated, and this was in accordance with the author's plan, which was to prepare a book expressly for students acquiring these languages. It is, therefore, properly "A Classical Student's Ancient Philosophy," and the author intends it for "undergraduates at the university," or others who are commencing the study of the philosophical works of Cicero, Plato, or Aristotle, in the original language." Nothing could certainly be more sensible than to furnish them at the outset in English what they propose to get in the original, but by all experience very rarely do get. The author complains of his own bewilderment in early student days when he was put upon the works of the classical masters, and proposes to help those similarly situated. But the question remains, Is it worth while, after all, to go beyond what is communicable in English?

Professor Mayor, of course, thinks it is, as he is an inveterate classicist; but he furnishes a fine example of the blinding and distorting bias of classical studies. Having given his life to the study of the ancients, all his feelings go in the direction of his work, so that he has become a devout worshiper of the ancients. We will not say that Professor Mayor is *ignorant* of modern science, but it is obvious that from his classical prejudices he has but little interest in it, but little sympathy with it, and therefore no just appreciation of its proper influence or true value. The author is a Professor of Moral Philosophy in King's College, and ought, therefore, to be intelligent on this subject, yet he says: "Is there any modern work of systematic morality which could be compared with Aristotle's 'Ethics,' for its power of stimulating moral thought? Most moderns appear to write under the consciousness that they are uttering truisms; or, if they escape from this, it is by running off from the main highway of morality into by-paths of psychology, or physiology, or sociology." Does he think, then, that the laws of mind, the laws of life, and the laws of social relations, as determined by modern science, have no bearing upon the laws of human action and conduct? Have the nature, constitution, and conditions of man nothing to do with his obligations?

The author agrees with Clement of Alexandria that "philosophy was to the Greek what the law was to the Jew, the schoolmaster to bring him to Christ"; but to what

moral end bring anybody to Christ, if, as he elsewhere says, "there is a freshness and a completeness about the ethics of the ancients which we seek in vain in the moderns"? Again, he remarks, "We might be spared much of crudeness and violence and one-sidedness, if people were aware that what they hold to be the last result of modern enlightenment was, perhaps, the commonplace of two thousand years ago." But would it not be better if we could be spared something more of that crude, one-sided education which disqualifies its victims from understanding what are "the last results of modern enlightenment"?

ANNUAL REPORT OF THE CHIEF SIGNAL-OFFICER TO THE SECRETARY OF WAR, FOR THE YEAR 1879. Washington: Government Printing-Office. Pp. 782, with Seventy-four Charts.

THE report claims that the duties of corps analogous in their service to the Signal Corps become more prominent with each ensuing year, and hardly a month passes without some improvement in apparatus deserving the attention of the office being suggested. Instruction on the subjects bearing on the duties of the service is given regularly at Fort Whipple, Virginia, whence it is intended a supply of well-drilled men shall be kept to draw from for the needs of the work. The men of the Signal Corps being engaged on duty as constant in time of peace as in the presence of actual war, return, it is admitted, more than the cost of the service, and are at the same time kept in readiness for any emergency of armed duty by regular drills. The value of the advantages gained by the existence of a corps so trained and having its experts distributed as they are over the country, can hardly be estimated; and the adoption of the exercises and practice of the corps is recommended to the militia of the several States. The office is in communication with numerous foreign correspondents, has official relations with the scientific men and chiefs of meteorological services of nearly every prominent power in the northern hemisphere, has become the acknowledged center of meteorological information on the continent, and has connected itself with the meteorological work of the world. It had, at the date of the report, two hundred and twenty-nine stations in the United States, and also received reports from twenty stations in Canada and British America. The summaries of the reports from these stations, which are published in the volume, illustrate the variety of ways in which the stations have made themselves useful and beneficial to the people and interests of the localities in which they are situated.

FIRST ANNUAL REPORT OF THE ASTRONOMER IN CHARGE OF THE HOROLOGICAL AND THERMOMETRIC BUREAUS OF THE WINCHESTER OBSERVATORY OF YALE COLLEGE, 1880–'81. By LEONARD WALDO. New Haven: Tuttle, Morehouse & Taylor. Pp. 32.

THE tests for watches are more stringent in some points than those made at Neufchâtel and Geneva, but a uniform standard is declared desirable. The time, as determined at the observatory, has been made by law the standard for the State of Connecticut, the first instance in the United States in which a State standard of time has been officially adopted. The testing of thermometers has been so satisfactorily done that the makers, particularly the makers of physicians' thermometers, have accepted the authority of the observatory as final, and have greatly improved under its encouragement. Thus, while in June, 1880, all the thermometers received were in error over one third of a degree, and two per cent. of them had errors exceeding a whole degree, in April and May, 1881, four fifths of all sent had errors of less than three tenths of a degree. The experiments indicate that the majority of physicians' thermometers in use are from one half a degree to two degrees too high.

REPORT OF FIELD EXPERIMENTS WITH FERTILIZERS. By Professor W. O. ATWATER, Wesleyan University, Middletown, Connecticut. 1881. Pp. 56, including five tables.

THE investigations have now been conducted for four years, both in the form of general experiments involving the use of seven or eight or more different kinds and mixtures of fertilizing materials, containing nitrogen, phosphoric acid, and potash, for the purpose of ascertaining what fertilizing

ingredients would most benefit the several soils and crops; and in the form of special experiments of a more complicated character, for the study of the feeding capacities of some of the more common plants, with special reference to the nitrogen supply. The present report gives the results for 1880.

REPORT OF PROFESSOR SPENCER F. BAIRD, SECRETARY OF THE SMITHSONIAN INSTITUTION, FOR THE YEAR 1880. Washington: Government Printing-Office. Pp. 83.

WITHIN the few pages of this publication are reviewed very briefly the transactions of the Institution in connection with numerous enterprises and interests bearing upon the advancement of science. Among them are the announcement of astronomical discoveries by telegraph; the exchange and distribution of publications and specimens; explorations in New Mexico, the West Indies, Arizona, Oregon, the Pacific coast, and Alaska; the Howgate Arctic Expedition; the publication of the twenty-second and the near readiness of the twenty-third volumes of "Contributions"; the publication of the sixteenth, seventeenth, eighteenth, and nineteenth volumes of "Miscellaneous Collections"; the transactions of the National Museum and the growth of its collections; and the work of the United States Fish Commission.

A SHORT HISTORY OF THE BIBLE. Being a Popular Account of the Formation and Development of the Canon. By BRONSON C. KEELER. Chicago: The Century Publishing Company. Pp. 126.

THIS is an inquiry into the origin and development of the doctrine of divine revelation, "beginning with a time when the books composing the Bible were not considered inspired, and following the belief, in the light of history and approved scholarship, from its inception to the present day." It aims to show who first affirmed the books to be inspired, who compiled them into the accepted volume, what changes have taken place in the canon, and "who first affirmed that we must believe the Bible or be damned." The author says that he has no theory to advocate, but he is evidently opposed to the doctrine of inspiration.

THE SPELLING REFORM. Circulars of Information of the Bureau of Education, No. 7, 1880. Washington: Government Printing-Office. Pp. 36.

THE statement embraced in this publication was prepared at the request of the United States Commissioner of Education by Professor F. A. March, of Lafayette College, President of the American Spelling Reform Association. It reviews the reasons for the spelling-reform movement and its history; explains the plan proposed by the American Philological Association, in accordance with which a large part of the essay is printed; gives a list of special words for which the Philological Society of England has proposed a reformed spelling, and catalogues the literature of the subject.

ENGLISH HISTORY FOR YOUNG FOLKS, B. C. 55 TO A. D. 1880. By S. C. GARDINER, Honorary Student of Christ Church, and Professor of Modern History at King's College, London. Edition revised for American Students. New York: Henry Holt & Co. Pp. 457.

THE subject is presented in an easy, flowing style, designed to engage the attention and hold the interest of young readers. With this purpose, important events have been given in fuller detail than usual, though no story has been told simply because it is interesting, and much has been omitted that would be merely burdensome to the memory. The character of the revision that has been made for American readers is not defined, nor is the necessity for it explained.

ON MAXIMUM SYNCHRONOUS GLACIATION. By W. J. McGEE, of Farley, Iowa. Pp. 65.

THIS is the substance of a paper which was read by the author at the Boston meeting of the American Association reviewing what is known as the "ice-cap theory." It endeavors to show, from the mode of operation of the agencies which effect glaciation, that precipitation over the central parts of any extensive ice-field must be very slight or even *nil*, and that there is no sufficient reason for believing that the polar regions were ever much more extensively glaciated than at present; and that the assumption

of a vast polar ice-cap to force outward the peripheral portion of the ice that may have accumulated in any latitude is unnecessary and incompetent. The viscous theory of ice-motion is adopted, with some modifications, and some of the most serious objections to it are considered.

CIRCULARS OF INFORMATION OF THE BUREAU OF EDUCATION. 1881. No. 1. THE CONSTRUCTION OF LIBRARY-BUILDINGS. Pp. 26. No. 2. THE RELATION OF EDUCATION TO INDUSTRY AND TECHNICAL TRAINING IN AMERICAN SCHOOLS. Pp. 22. Washington: Government Printing-Office.

THE first of these circulars is the paper on the construction of library-buildings, which was read by Mr. William F. Poole, of Chicago, at the last meeting of librarians in Washington. Its object is not to formulate rules that must be rigidly followed, but to set forth the conditions for library-buildings which experience has shown to be indispensable.

The second circular embraces papers which have been prepared by President White, of Purdue University, Lafayette, Indiana, on the two subjects of "Technical Training in American Schools" and "The Relation of Education to Industry."

THE DISPOSAL OF THE DEAD: A PLEA FOR CREMATION. By EDWARD J. BERMINGHAM, M. D. New York: Bermingham & Co. Pp. 89. Price, $2.

THE purpose of this volume is to give an exposition of the present state of the subject of cremation in public discussions, to point out the supposed evils of inhumation, to assist in removing the prejudice against cremation, and secure new friends for it. After considering the different methods of disposing of the dead, and the inconveniences of burial, it reviews the history of cremation among ancient nations and in modern times; considers it from a sentimental point of view, showing its consistency with the best and holiest feelings with reference to the dead; furnishes descriptions of the process and of the different apparatus in use; shows how economical and salutary it would be to cremate dead animals and garbage; and closes with a summary of the arguments on both sides of the question.

PLIOCENE MAN IN AMERICA. By JAMES C. SOUTHALL, A. M., LL. D., of Richmond, Virginia. Being a Paper read before the Victoria Institute, or Philosophical Society of Great Britain. With Remarks by the Duke of Argyll, Professor W. Boyd Dawkins, Principal Dawson, Professor T. McKenny Hughes, and others. New York: A. D. F. Randolph & Co. Pp. 30.

THE author takes up the cases of human relics that have been found in California in such situations and under such circumstances as to cause a pre-glacial antiquity to be assigned them, and argues to show that that conclusion is not necessary, and that there is nothing in either the situation or condition of the relics to make a post-glacial origin impossible or even improbable.

REPORT ON THE COTTON PRODUCTION OF THE STATE OF LOUISIANA, WITH A DISCUSSION OF THE GENERAL AGRICULTURAL FEATURES OF THE STATE. By EUGENE W. HILGARD, Professor of Agriculture at the University of California (extra "Census Bulletin"). Washington: Government Printing-Office. Pp. 99.

THIS report is intended to form a part of the complete report on the cotton-culture of the United States shortly to be issued. It is designed for the information of the general public, as well as of the statistician and student, and is therefore thrown into a popular form. The author is surprised that so few State surveys have popular use of the results of their systematic investigations in view, but has always in his own work considered this the most important object to be compassed. Were it always sought, State surveys, he believes, would be more popular, better sustained, and therefore more complete.

THE YOUNG FOLKS' ASTRONOMY. By JOHN D. CHAMPLIN, Jr. New York: Henry Holt & Co. 1881. Pp. 236. Price, 60 cents.

THE author of this book says, "There can be little question of the propriety of early grounding a child in an elementary knowledge of the astronomical features of the earth on which he lives and of the universe of which it forms a part." He adds also that the "primers" hitherto made for the purpose are failures. In this he is right, and his own book will have to take its place

among them, for the reason that he is wholly wrong in what he says of the propriety of grounding children in a knowledge of the astronomical relations of the earth to the universe. The reason of this is that the immature mind can not grasp that order of ideas, and ideas that can not be clearly seized are not suitable for educational purposes. A child sees the sun, moon, and stars, and may be curious to ask questions about them, but that is no evidence that it can *comprehend* those truths about them that it took thousands of years to discover, and which it still tasks the adult mind to understand. A child sees also that fire converts water into steam, but it is not, therefore, competent to take in, even in its rudiments, the science of thermo-dynamics. The child can learn words, and astronomical words just as well as any, because the power of verbal acquisition is quite independent of any meaning that may be attached to words. This learning of mere words and the passing off verbal statements for knowledge is the bane of education; and nowhere will this mischievous result be more certain than in the attempt to teach children astronomy. Nevertheless, parents will be flattered to see their wonderful little prodigies at the same time in breeches and astronomy, and so Mr. Champlin's neat little book will no doubt be a "success."

THE TOTAL SOLAR ECLIPSE OF JULY 29, 1878. Observations at Pike's Peak, Colorado. Report of Professor S. P. LANGLEY. Pp. 15, with Plate.

THE most interesting features of Professor Langley's observations were the narrow, structureless ring of vivid light around the sun, which faded suddenly into a nebulous luminosity, extending for two and a half solar diameters all around; and a stream of light with parallel borders extending to three and a half diameters on one side and six diameters on the opposite side, in a direction nearly corresponding with that of the ecliptic, which were seen with the naked eye; and a coarse, sharply defined filamentary structure in the corona seen through the telescope. Some of Professor Langley's assistants observed very peculiar and striking color-phenomena in the clouds during the moment of the coming on of totality.

PAPERS OF THE ARCHÆOLOGICAL INSTITUTE OF AMERICA. AMERICAN SERIES, I. 1. HISTORICAL INTRODUCTION TO STUDIES AMONG THE SEDENTARY INDIANS OF MEXICO. 2. REPORT ON THE RUINS OF THE PUEBLO OF PECOS. By A. F. BANDELIER. Boston: A. Williams & Co. Pp. 135, with Plates.

THIS handsomely printed and finished volume gives a favorable introduction to the society under whose auspices it is put forth and of which it is the first publication. The first part gives the history of the Pueblos from the time they are first mentioned by the Spaniards, and the theories that have been urged and inquiries made respecting them. The second part gives the results of the author's examinations, surveys, and measurements of the ruins of the Pueblo in the valley of the Rio Pecos, with views, plans, sections, and estimates, and observations such as the information at hand makes appropriate concerning the character, customs, and arts of the Indians who constructed the buildings.

MATERIALISM ANCIENT AND MODERN. By a late Fellow of Trinity College, Cambridge. New York: Macmillan & Co.

THIS essay of forty-three pages, in large type, is a very commonplace argument intended to be opposed to materialism, and its quality is as slight as its form. It can help nobody.

SEA-MOSSES: A COLLECTOR'S GUIDE AND AN INTRODUCTION TO THE STUDY OF MARINE ALGÆ. By A. B. HERVEY, A. M. Boston: S. E. Cassino. 1881. Pp. 281. Price, $2.

THOSE who live by the sea, and those who frequent the seaside for recreation and health during summer vacations, if they have any desire to improve their opportunities for improving their minds, are placed under obligations to Mr. Hervey for the preparation of this volume. The author thus indicates his object: "I have attempted to make a book which should be a real and helpful guide to those who, though not expert botanists, and not having or using any aids to a good pair of eyes other than a simple pocket magnifier, desire to begin the collection and study of marine plants." The author has been freely assisted by many

adepts in this fascinating study, and he has evidently spared no pains in preparing his manual, as his publisher has certainly spared no expense in illustrating it.

PUBLICATIONS RECEIVED.

Education in Charleston, South Carolina. The Disabilities of the Unaided South in Public School Facilities. Published by the City Council. 1881. Pp. 32.

The Gesture Speech of Man. Address of Colonel Garrick Mallery, U. S. Army, before the American Association for the Advancement of Science. Salem, Massachusetts. 1881. Pp. 33.

The Duties of Women. By Frances Power Cobbe. Boston: George H. Ellis. 1881. Pp. 198. 25 cents.

Annual Report of the Surgeon-General of the U. S. Army. Washington. 1881. Pp. 23.

Reform in Medical Education. Annual Address before the American Academy of Medicine at New York. By Edward T. Caswell, M. D., President. Philadelphia. 1881. Pp. 16.

Circulars of Information from the Bureau of Education, No. 3. 1881. Washington: Government Printing-Office. Pp. 79.

Study of the Sphecidæ; List of the North American Larradæ: Notes on the Philanthinæ. By W. H. Patton. Pp. 28.

Education and Crime, pp. 10; The Discipline of the School, pp. 15. Bureau of Education. Washington: Government Printing-Office. 1881.

On the Filling of Amygdaloidal Cavities and Veins in the Keweenaw District of Lake Superior. By M. E. Wadsworth, Ph. D. Pp. 12.

The Areas of the United States: The Several States and Territories and their Counties. By Henry Gannett, E. M. Washington: Government Printing-Office. 1881. Pp. 20. With Map.

The Kinematics of Machinery. By Professor Alexander B. W. Kennedy, C. E. With an Introduction by Professor R. H. Thurston, C. E. New York: D. Van Nostrand. 1881. Pp. 88. 50 cents.

Malaria: What it Means and how Avoided. By Joseph F. Edwards, M. D. Philadelphia: Presley Blakiston. 1881. Pp. 81.

The Nature and Function of Art, more especially of Architecture. By Leopold Eidlitz. New York: A. C. Armstrong & Son. 1881. Pp. 403. $4.

The New Infidelity. By Augustus R. Grote. New York: G. P. Putnam's Sons. 1881. Pp. 101. $1.25.

Dangers to Health: A Pictorial Guide to Domestic Sanitary Defects. By T. Pridgin Teale, M. A. Third edition. Philadelphia: Presley Blakiston. Pp. 170. $3.50.

The Honey Ants of the Garden of the Gods, and the Occident Ants of the American Plains. By Henry C. McCook, D. D. Illustrated. With Thirteen Plates. Philadelphia: J. B. Lippincott & Co. 1882. Pp. 198. $2.50.

Elements of Quaternions. By A. S. Hardy, Ph. D. Boston: Ginn & Heath. 1881. Pp. 230.

A Study of the Pentateuch for Popular Reading. By Rufus P. Stebbins, D. D. Boston: George H. Ellis. 1881. Pp. 293. $1.25.

Ecce Spiritus. A Statement of the Spiritual Principle of Jesus as the Law of Life. Boston: George H. Ellis. 1881. Pp. 298. $1.25.

Sparks from a Geologist's Hammer. By Alexander Winchell, LL. D. Chicago: S. C. Griggs & Co. 1881. Pp. 400. $2.

The League of the Iroquois and other Legends from the Indian Muse. By Benjamin Hathaway. Chicago: S. C. Griggs & Co. 1881. Pp. 319. $1.50.

Higher than the Church. An Art Legend of Ancient Times. By Wilhelmine von Hillern. From the German by Mary J. Safford. New York: William S. Gottsberger. 1881. Pp. 74.

Mechanics' Liens. How Acquired and Enforced. With an Appendix of Forms. By James T. Hoyt, of the New York Bar. New York: P. F. McBreen, printer. 1881. Pp. 310.

Zoölogical Atlas, including Comparative Anatomy, with Practical Directions and Explanatory Text. By D. M'Alpine, F. C. S. With 231 Colored Figures and Diagrams. Vertebrata. Edinburgh and London: W. & A. K. Johnston. 1881.

Report upon United States Geographical Surveys west of the One Hundredth Meridian. Vol. VII, Archæology. By Frederick W. Putnam. Washington: Government Printing-Office. 1879. Pp. 497. Illustrated.

POPULAR MISCELLANY.

Finding the Center of Population.—The computation of the center of population of a country, as explained by Mr. F. D. Y. Carpenter, who has performed the work for the United States, for the census of 1880, is not a simple or an easy process. As defined in the "Statistical Atlas" of 1874, this center is the point at which equilibrium would be reached were the country taken as a plane surface, itself without weight, but capable of sustaining weight, and loaded with its inhabitants, each individual being assumed to be of the same gravity as every other, and consequently to exert pressure on the pivotal point directly proportioned to his distance therefrom. In other words, it is the center of gravity of the population of the country. It may be illustrated otherwise, by saying that it is the point at which, if all the population should assemble, the aggregate distance traveled by all those coming from any two opposite points of the compass would be respectively equal. It is found approximately by assuming a point as nearly as possible to the true position of the center, and then finding its north, south, east, and west moments of population; that is, the four aggregate products formed by multiplying the local populations by the distances of their centers north and south of the assumed parallel, and east and west of the assumed meridian. The sums of the north and south moments, and those of the east and west moments should be severally equal to each other. The differences which will appear between the several sums in the

trial-work, divided by the total population of the country, will give the measures of correction to be applied to the assumed point, in order to deduce the true center from it. In the case of a population so extensively and diversely scattered as that of the United States, there is room for any amount of refinement in the details of the calculation. The larger cities are treated as special centers. Leaving them out, the population of the country is grouped by square degrees—that is, by the spaces included between two consecutive degrees of latitude and of longitude, the centers of which, except where there are reasons for exception, are taken as the local centers of population. By this process, the center of population of the United States for 1880 is placed in latitude 39° 4′ 8″ and longitude 84° 39′ 40″, or at a point in Kenton County, Kentucky, one mile south of the Ohio River, and eight miles west by south from the heart of the city of Cincinnati. This location is, after all, only approximate, and extreme accuracy is hardly attainable under ordinary modes of calculation. In fixing it, the surface of the country has been assumed to be plane, whereas it is spherical or spheroidal, and a parallel of latitude has been made one of the axes, whereas the arc of a great circle should have been taken. Then there are differences in the kind of map-makers' projections that are used, all distorting the spheroidal surface in attempting to represent it as a plane, but some giving worse distortions than others. Mr. Carpenter believes that if it were practicable to make an absolutely correct calculation, the actual center would be found about thirty miles to the north and a trifle to the east of the present estimated location, or in Butler County, Ohio. The center is thrown so near the northern boundary, by the fact that our country in general shape is the segment of a zone; and the case is supposable, if the segment were extended far enough in longitude, in which the center of population would be situated entirely outside of the country.

Movements of Plants. — Mr. Thomas Meehan, of Philadelphia, has recently noticed some apparent irregularities in the motility of various plants which have not been adequately accounted for. The expansion and closing of the petals of *Draba verna*, which take place in connection with the diurnal erection and drooping of the pedicle, appear to require a clear light; yet while at one time the expansion seemed to be prevented by a cloudiness that hardly dimmed the sun's rays, it was at another time not at all interfered with during a densely cloudy, warm, and moist day that followed a thunder-shower. The earliest flowers of *Lamium amplexicaule* are the largest ones in the Isle of Wight; here the case is reversed: the flowers never expand; and plants alongside of each other under the same conditions and external influences vary a week in the time of their flowering. The drooping branches of the Kilmarnock willow have grown from the upward branching *Salix caprea* without any known external influence to determine a different direction of growth, and they bear erect catkins, while erect branches bear pendulous ones. Such facts should teach us that external causes have but little influence with motility, and that in many cases a combination of circumstances controls the influences attributed to one. The facts will vary with various observations—those of one observer seeming rather to conflict with than to confirm another—and it is too soon to form any conclusion as to the motive cause.

Inscriptions of the Mound-Builders.—Major William S. Beebe, of Brooklyn, gave an interesting account, at the recent meeting of the American Association, of his efforts to decipher the inscriptions that have been found in the mounds at Davenport, Iowa, and Piqua, Ohio. Two pieces of slate were found in a mound at Davenport, one of which was inscribed on one side, the other on both. The stone inscribed on but one side bore on its surface a series of concentric circles, between the outer two of which were twelve equidistant signs, presumably the zodiacal signs. About two years after these slates were found, two terra-cotta tablets were dug up at Piqua, Ohio, bearing series similar to each other of characters, "evidently letters," ranged in horizontal lines, on four of which the letters were in each case six in number. In the fifth and remaining instance there were five lines,

but this arrangement was at some distance in the longitudinal direction of the tablet from the groups first mentioned, which were in both cases written in couples. Major Beebe claimed that these groups of six letters each, when separated into alternate threes and read right and left respectively, are the names of eight of the zodiacal signs on the Davenport slate—the other four signs, Capricorn, Aries, Cancer, and Libra, being represented by four initial letters on the back of one of the Piqua tablets. These letters represent the North, South, East, and West, respectively, and correspond to the "world-holders," as they were called, to which a particular importance was attached. The most significant detail of this identification is that the forms of the letters are almost precisely those that occur about the Mediterranean, whose phonetic values have been determined by Alois Hess in his work on the classification of old Spanish coins. Should this identification be correct, the point arises whether this alphabet originated in this country or in the old. Major Beebe claims to have traced each form of letter to aboriginal American picture-symbols, in which the same significance obtains in both European and American forms. Having fixed the significance of the letters, he has, he says, deciphered the inscription on the stone from Grave Creek, West Virginia, and that on the axe found at Pemberton, New Jersey.

Cremation in Italy.—As an evidence of the progress which cremation is making in Italy, the Journal of the Italian Hygienic Society states that one hundred and thirty-nine cremations have taken place in the crematories at Milan and Lodi, and that the number increases every month. Nine societies and nine committees for cremation exist in the kingdom, and new crematories are to be built at Rome, Varese, Leghorn, Pavia, Cremona, and Udine. Signor Loria, of Milan, has recently offered the municipality of the city twenty thousand francs for the establishment and maintenance of a laboratory for making autopsies of bodies destined to be incinerated when that is deemed expedient, or may be called for by the circumstances of the case. The French Government apparently does not favor the movement much. To a petition from the municipality of Paris, asking permission to incinerate bodies in certain cases, the Minister of the Interior replied that the law of the year XII, prescribing burial, would have first to be repealed, and the Government did not consider that the question had yet been enough studied by science or advanced in public opinion to justify the assumption of the responsibility of presenting it to the legislative bodies.

Sanitation of Cemeteries.—The Municipal Council of Paris in 1879 appointed a commission on the sanitation of cemeteries, with instructions to inquire especially whether that object could not be fully accomplished by the employment of chemical or physical agents combined with drainage; whether it could be assured for the future by the same means; and whether the disappearance of the organic parts of bodies could not be expedited by the addition, in the coffins or the soil, of chemical agents and other substances; and whether such additions were likely to do any harm. This committee, after a careful examination of the soil and air within the cemeteries and around them, has reported that, though accidents may have occurred from the escape of gases in close tombs and churches where bodies have been buried, they are not to be feared in the open air; that deleterious gases produced by the decomposition of corpses buried at the depth of a metre and a half (five feet) do not reach the surface; that nearly the entire organic constituents of dead bodies are consumed in the course of five years, and that consequently a tolerably permeable soil is not likely to be saturated; that this consumption may be accelerated by drainage; and that there is no danger to wells if they are at a reasonable distance away. These conclusions agree fully with those expressed by M. Robinet in his article "Are Cemeteries Unhealthy?"* They may possibly be modified in consequence of the researches that have brought the cadaveric alkaloids, the *ptomaïnes*, to light, and of M. Pasteur's discoveries concerning the preservation of carbuncular germs in the soil.

* Published in the "Popular Science Monthly" for September, 1881.

Rodents, Fossil and Living.—M. E. L. Trouessart, in attempting to explain the geographical distribution of living and fossil rodents from the point of view of the doctrine of evolution, divides the living rodents into four principal groups, or tribes: the cosmopolitan rats and their allies, which appear to find everywhere and under all circumstances conditions favorable to their existence and multiplication; the sciuromorphs (squirrels and marmots) and the lagomorphs (hares), almost exclusively of the northern hemisphere; and the hystricomorphs (porcupines, Guinea-pigs, and capybaras), which are now confined to the southern hemisphere. The study of the fossil rodents shows that these four types were neither as narrowly confined to particular regions nor, except the hares, as clearly defined and separated from each other as now. The types of the southern hemisphere were represented during the Miocene epoch in the north of both continents, and appear to have been driven south by glacial cold. The existing types of rodents first appear in the Eocene epoch, and by the side of them mammals with similar dentition, of which the chiromys of Madagascar may be regarded as the last survivor. Some of the mammals of the secondary epoch present the characteristic incisors of the rodents, with molars indicating a carnivorous or at least a more omnivorous nature than that of the great majority of the modern rodents. Similar incisors are found in a number of insectivorous animals, as, for example, among the shrew-mice and several types of ungulates. We are thus led to conclude that this type of the rodents played at the beginning of the Tertiary period an important part in the history of a number of orders which have now become more specialized.

Whales and their Habits.—A correspondent of "Land and Water," who accompanied the Dundee whaling fleet to Davis Strait and Lancaster Sound last summer, mentions the change that has taken place in the geographical distribution of the Arctic whale. A century or two ago this animal was found everywhere north of the sixtieth degree of latitude, and extended many degrees farther south on the east coast of America. It abounded on the northern shores of Europe and the coasts of Iceland and Greenland, frequenting the islands of Jan Meyen and Spitzbergen in incredible numbers. Now it has deserted Spitzbergen and the north of Europe, it is becoming rare on the coasts of Greenland, and seems to be retiring farther into the unpenetrated recesses of the Polar Sea. Whalemen are not agreed as to whether the animals are actually diminishing in numbers. Some believe that they are still as numerous as they were at the beginning of the century; others predict that the time of their total extinction is approaching. They are still sometimes seen in enormous numbers. Whales exceeding forty-seven and forty-eight feet in length are caught every year. Captain Deuchars, of the Dundee fleet, two years ago took a whale sixty-five feet long, the "bone" of which measured twelve feet ten inches, and which gave twenty-four tons of pure oil. The largest whale ever caught in Davis Strait, in 1849, had a "bone" fourteen feet long, and yielded twenty-seven tons of oil. The destruction of "suckers," or baby whales, which is considerable, may have something to do with the present decadence of the fishery. Whalemen think that no animal should be killed whose "bone" is not more than six feet long. Whales may live to a very great, but no one knows to how great, an age. Although dead ones are often found floating on the water, none are ever discovered that have died from natural causes. Whales are monogamous, and are much attached to their consorts. The correspondent who furnishes these facts tells of an animal which came back every day for a fortnight through great peril from the fleet to the place where its mate had been taken, regularly going over the course followed by her in her flight, looking for her. The animals sleep on the surface of the water, enjoy fine weather and sunshine, and are often seen at play on bright days. When they are together in large numbers, the water becomes covered with an oily exudation from their bodies, which has a sickly smell, and attracts flocks of "molly" petrels. They can live only on the most minute marine animals, for, though a whale's mouth "would hold a whale-boat, with all its crew, its gullet would be choked by a herring. When feeding, it swims through

the water with its mouth wide open, a constant stream passing in at the front, through the upright whalebone plates at the sides, and out again at the back. The small animals which form its food are entangled in the long hairs which fringe the internal edges of the plates, and from time to time, as they become collected in sufficient numbers, the whale closes its mouth, raises its tongue, and swallows the mass." Its favorite food is a black pteropodous mollusk, resembling a humble-bee, and, after this, jelly-fish, of which it takes millions to make a meal. Fortunately for the whale, these creatures go closely massed together in shoals many square miles in extent. After man, the whale's worst enemy is the grampus, which attacks it savagely, and is very destructive to the species. Its protection from both enemies is the ice; and it is, consequently, now found almost exclusively in the neighborhood of ice.

Typography and Eyesight. Dr. Javal considers the subject of typography in relation to the hygiene of the eyes in the "Revue Scientifique." His conclusions differ materially only in a few points from those which Professor Herman Cohn has published. He believes it important to make the several letters, particularly those which are allied in form, as distinct as possible, and therefore favors those fashions in the cutting of the types which tend to accentuate the distinctions. The superior importance of the upper part of the letters, which is generally recognized, is enforced by the fact that in the case of the irregularities in the lines occasioned by the "long letters," eighty-five instances occur in which the long strokes rise above the line to fifteen in which they fall below it. Of the groups of letters resembling each other the members of the one composed of *a*, *e*, *c*, *o*, and *s*, are most likely to be confounded with each other, and more clear distinctions in the formation of their upper curves are eminently desirable. The strokes of which the letters are composed should not be made so thick as to blur the figure of the whole letter, which is the feature the practiced reader regards; and only young readers require a particularly heavy stroke. The thin lines that cut off the strokes at either end are not without importance; and Dr. Javal prefers the English method of drawing them so as to leave a curve between the stroke and the line, to the French method of leaving a sharp angle. These lines may be used with good effect, with slight variations in their position to assist in marking distinctions between letters which are otherwise somewhat alike. Dr. Javal regards the width of the letters as of more importance than their height, and the spacing between them as of more moment than the separation of the lines by leads; he does not consider leaded matter as really more legible than "solid"; and he ascribes a superior legibility in English books to the predominance of short words, giving more horizontal spacing. He would prefer a large type "solid" to a finer type leaded, although he admits that a "solid" page has a blackish, heavy, and somewhat disagreeable aspect. If attention is paid to his views regarding the breadth of the letters and the inter-literal spacing, he believes that the height, in the case of ordinary reading matter, may be considerably reduced without marring the legibility. Different considerations must prevail in regard to school-books, in which the typography must vary according to the age of the pupil, within limits which can be determined only by experience.

Accommodative Cultivation of Infectious Organisms.—Dr. A. Wernich has considered, in "Kosmos," the extent to which the molds, the microbic parasites of the body, and the germs of infection, are able to adapt themselves to new conditions of existence, assume new forms, and produce different effects. When microbes are observed in great numbers, as they may be sometimes in the tissues and secretions even of healthy persons, much more of sickly ones, the temptation is very strong to associate them with the production of disease, and is apt to mislead. Naegele has expressed himself in favor of the doctrine of transformation, and says that the same fungoid, transferred successively from one medium to another, may produce, in milk, lactic acid; in meat, putrefaction; in wine, gum; in the ground, nothing; in the human body, disease; and that it may, in each

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place, gradually adapt itself to the new conditions, and even, in the course of successive transformations, acquire new facilities for adaptation. If four vessels, carefully cleansed, are filled with different fluids —such as carbolic acid, urine, Cohn's mineral plant-food, and Pasteur's fluid — all clear of bacteria, and a drop of the same putrefactive mixture is added to each of them, they will, in the course of forty-eight hours, show very different degrees of disturbance, according to their adaptation to promote the growth of the infective organisms. If the organisms themselves are examined, they will be found, although all originating from the same source, to be only similar, not identical. Even Pasteur, who stoutly advocates the specificity of the ferments, has been obliged to admit a few exceptions to his theory. Dr. Wernich had already called attention to observations by himself and others which tended to show that fungoids, which seemed harmless growths on the more exposed tissues, might, if the capacity of the body for resistance should be depreciated, become aggressive, and develop dangerous disorders. Grawitz cultivated a mold that grows on sour solids, but does not flourish in the bodies of animals, through successive generations, till he adapted it to a higher temperature than its natural one, to pastes, sweetened and alkaline fluids, and to blood. A living animal inoculated with spores of the last variety died in a few hours in consequence of a general development of the fungoid vegetation, particularly in the kidneys and liver. Dr. Wernich believes that he has evidence that the strength of the infective qualities of these organisms may be greatly increased by an accommodative culture. Cultivation in substances unfavorable to their growth is, on the other hand, found to cause a depreciation of their inoculative efficacy. If we select the most favorable substance for the growth of a mold, and plant upon it the most vigorous stocks we can obtain, we will soon perceive unmistakable indications of an increase of vigor. The period required for the development of the germs is shortened, and the organisms give way to their successors of the next generation in continually diminishing periods. The infective force becomes so much greater that the slightest contact is sufficient to effect a transplantation to a new medium, and the greatest pains are necessary to prevent a transfer without apparent contact of spores of the same kind as those which, subjected to unfavorable conditions of culture, require painful attention to induce them to take root in any new soil. A similar development of activity and infective power may be observed in the case of epidemics. The germs of disease do not exhibit their full vitality at once, as do poisons when absorbed, but require a period of incubation and the favor of diminished power of resistance in the body before they can exhibit their full effect. The first cases are indefinite, and hardly recognizable in their real character, and affect only the weakly; as the epidemic acquires strength, its manifestations are more determinate, and it affects all. The manner in which this growth of activity is produced may be illustrated by experiments that have been made in the inoculation of animals, in which an increase in infective power has been very distinctly perceived to accompany each successive transfer from one animal to another. Dr. Wernich suggests that there are some questions relating to the subject that need yet to be explained, and that it will not be safe to form definite conclusions upon it until after further investigation.

Explosive Force of Coal-Dust.—The Rev. H. C. Hovey has communicated to the "American Journal of Science" the results of the investigations of Mr. Gilpin, Inspector of Mines for Nova Scotia, into the part played by coal-dust in spreading and augmenting the explosions which took place in the Albion mine in November of last year. The mine was thoroughly ventilated, and was reported by the night-watchman, an hour before the explosions began, to be free from gas, except in small and harmless quantities. Yet the explosions, once begun, were continued at intervals till the mine was all aflame and had to be flooded. On examining the gallery shortly after the original explosion, dead bodies of men and horses were found six hundred yards from the shafts, and the wood-work was splintered, but nothing bore any marks of fire, "and the conclusion was plainly justifiable that

the flame of the explosion had not extended thus far. The walls of the galleries had been swept clear of timber, and presented the appearance of having been brushed with a broom. Volumes of coal-dust had been driven along by the force of the blast, and lay in waves and drifts on the floor of the levels, into which the party sank to their knees. It was found that clouds of the finer particles had been carried to the shaft and beyond it into the main north level, where a secondary explosion had taken place. . . . Secondary explosions caused by extracted or generated gas are nearly always in the vicinity of the first one; but here is a case where the second was half a mile from the first, with an intervening space of at least a quarter of a mile known to have been free from flame and presumed to be free from gas, because men were in it with lamps which showed no indications of its presence." The conclusion is drawn that the fine dry particles were driven on by the force of the first explosion across the shaft, where the dampness preserved them, into the "lamp-cabin," where they were readily ignited by the lamp which was kept burning openly, and thus caused the second explosion; "and it is probable that the same agency was efficient in producing, or at least augmenting, the subsequent explosions that made it necessary to flood the whole mine." A competent explanation on chemical principles of the remarkable exhibition of force and heat accompanying dust-explosions is needed.

Significance of Ancient Masons' Marks.—Professor Franz Rziha, of Vienna, has published the results of investigations, to which he has devoted many years, into the origin and meaning of the masons' marks which are frequent in the constructions of antiquity and the middle ages, and which he specifies as occurring in Grecian, Roman, and Syrian buildings, as well as in later ones. They have been regarded as mystic signs, arbitrary marks, private signs, or simply as letters. Professor Rziha believes that they had a far wider significance, and that they formed, before the now recognized laws of statics on which the building art rests were made known by Galileo, the means by which the master transmitted to his students the secrets of his art, and to his workmen the principles of his plan. Particular figures were employed as a kind of a graphic key to the conditions of a consistent structure. The circle, square, cross, and triangle furnished the four elements of graphic delineation; the compass, rule, and square were the three tools absolutely necessary to guide the work, and were indispensable in securing the proportions best adapted to give strength to all parts of the building. The geometrical properties and relations of the figures used thus served to indicate the proportions that were to be obtained. Professor Rziha maintains that the figures were never arbitrary, but that they were always derived from and conformable to common geometrical types. A comparison of more than five thousand masons' marks which he has made shows that, however independently individual signs may have been chosen, the combination of the lines is subject to a law in the shape of a geometrical pattern, of which the lines, whether straight or curved, must be a part. He has traced out some of these original designs, and has been able to adapt the lines of the marks to them without any artificial straining—in strong confirmation, he believes, of his theory. After reviewing the modifications which these marks underwent in time and in different countries, Professor Rziha shows how it is possible to ascertain from them the ages at which buildings were erected.

Physiological Immunities of the Jews.—The "Revue Scientifique" has drawn the conclusion, from a comparison of the vital statistics of different countries, that the Jews nearly everywhere enjoy certain physiological immunities which distinguish them from the other inhabitants, among which are the following: their general fecundity (proportion of births to the whole number) is less; while the relative fruitfulness of their marriages to those of other races varies in different places; a greater proportion of their children survive everywhere; illegitimate births and still-born children are more rare among them; the proportion of males to females among the births is greater; their mortality is lighter, the mean duration of life is greater; they increase more rapidly by the excess of births over deaths; while they

do not escape them entirely, they are less generally and less severely afflicted by contagious diseases; they are comparatively exempt from such diseases as consumption and scrofula; and they have the faculty of becoming acclimated and multiplying in all latitudes. These immunities are observed, notwithstanding the apparent condition of the Jews who enjoy them may be most miserable, notwithstanding the frequency of marriages of relatives among them, and notwithstanding the unwholesome conditions of the city life to which they mostly confine themselves. They may be explained as the consequence of the operation of a variety of causes, among which are suggested an inherent superior vitality in the race; the continued preservation of its purity from admixture with foreign blood; the faithful observance of the rules of hygiene laid down in Deuteronomy, which are particularly adapted to hot climates and hot seasons; the salutary influence of early marriages, of the spirit of order and economy, of moderation in tastes, of a comparative severity of manners, and of the domesticity of Jewish family life. It may be, too, that the misery in the Jewish quarters of European cities is more apparent than real, and that their inhabitants are really better off than the people around them. The facts are brought out in the statistics from which these conclusions are drawn, that Jews are quite liable to cerebral affections, and also to diseases that afflict mature and aged persons. The latter fact is explained by the existence of a greater proportion of mature and aged persons among them.

Constitution of Comet *b*, 1881.—The spectral phenomena and constitution of the comet were the subjects of several papers at the sessions of the French Academy of Sciences of June 27th and July 11th. Mr. Huggins stated that the lines as shown in his photographs indicated the presence of nitrogen with carbon and hydrogen, probably as cyanogen. M. Berthelot remarked that the exhibition of the lines of hydrocyanic acid would furnish an argument for the hypothesis of the electric origin of the light, as the spectra of acetylene and hydrocyanic acid are characteristic of the electrical illumination of a gas containing carbon, hydrogen, and nitrogen, whether free or in combination. M. Thollon described the nucleus as giving a brilliant continuous spectrum, and the nebulosity around the nucleus as showing three bands, one quite distinct, the others dim, separated upon a ground forming a continuous spectrum. The spectrum of the bands resembled that given by the blue flame of alcohol, and therefore indicated the presence of carbon or some of its compounds. M. Wolff recognized—1. A wide continuous spectrum, pale, but visible in all the regions of the comet; 2. A continuous spectrum, almost linear, lively bright, given by the nucleus; 3. The spectrum of the three bands—yellow, green, and blue—characteristic of the light of all the comets hitherto examined. The existence of a solid or liquid matter, luminous either by itself or by reflection, was indicated in the nucleus, and that of an incandescent gas, probably acetylene, in the surrounding nebulosity, while the light of the tail appears to come from a luminous or simply illuminated pulverulent matter. The polariscopic observations indicated the existence of reflected light, that is, of non-gaseous matter endowed with the power of reflection. M. Thollon noticed the modifications that took place in the spectrum as the comet receded from the sun. The violet rays were soon extinguished, while the yellow and red rays continued of full brilliancy. The bands appeared nearer the nucleus every day till the first day of July, when they were seen on the nucleus itself. M. Thollon supposes that the mass of the comet is formed partly of an incandescent gas, characterized by the banded spectrum, and partly of an incandescent solid or liquid matter in a state of extreme division, emitting a proper white light, and also capable of reflecting a part of the light it receives from the sun.

A South African River-Antelope.—Major Serpa Pinto, the African traveler, found on the Cuchibi a new antelope, of curious and remarkable habits. It bears, he says, among the Bihenos the name of *quichóbo* and among the Ambuellas that of *buzi*. It is of the size, when full grown, of a one-year-old steer, has dark-gray hair, extremely smooth, straight horns, about two feet long,

and set at a slight angle to each other, "twisted around the axis without losing their rectilinear shape," and terminating in a broad spiral. The feet are furnished with long hoofs similar to those of the sheep, and are curved at their points; and this arrangement, together with the sedentary habits of the animal, renders this remarkable ruminant unfitted for running. "Its life is therefore, in a great measure, passed in the water, it never straying far from the river-banks, on to which it crawls for pasture, and then chiefly in the night-time. It sleeps and reposes in the water. Its diving powers are equal, if not superior, to those of the hippopotamus. During sleep it comes near to the surface of the water, so as to show half its horns above it. It is very timid by nature, and plunges to the bottom of the river at the slightest symptom of danger. It can easily be captured and killed, so that the natives hunt it successfully, turning to account its magnificent skin and feeding off its carcass, which is, however, but poor meat. Upon leaving the water for pasture, its little skill in running allows the natives to take it alive; and it is not dangerous even at bay, like most of the antelope tribe. The female, as well as the male, is furnished with horns. There are many points of contrast between the life of this strange ruminant and that of the hippopotamus, its near neighbor. The rivers Cubangui, Cuchibi, and the upper Cuando offer a refuge to thousands of quichôbos, while they do not appear either in the lower Cuando or the Zambesi. I explain this fact by the greater ferocity of the crocodiles in the Zambesi and lower Cuando, which would make short work of so defenseless an animal if it ventured to show itself in their waters."

Does Sea-Water contain Free Carbonic-Acid Gas?—M. P. Martin Duncan maintains that carbonic-acid gas is not present in sea-water in a free state, and cites in support of his view Tornö, of the Norwegian Deep-Sea Expedition, who has been quoted, erroneously it seems, on the opposite side. It appears from a careful examination of Tornö's essay that that author, in the course of his experiments, found that sea-water had an alkaline reaction, and then began to believe that the carbonic-acid gas which had been taken from the water in other experiments had been produced by the decomposition of neutral carbonates during the boiling. He then proved by experiment that the saline mixture in sea-water, on the temperature being raised to the boiling-point, decomposed neutral carbonates, and that all previous experiments for measuring the carbonic-acid gas in sea-water had been faulty. Of ninety-seven milligrammes of gas per litre of water found in one specimen, he estimated that about fifty-three milligrammes entered into the formation of neutral carbonates, and that the remaining forty-four milligrammes, instead of occurring free as gas, united with the carbonates to form bicarbonates. In one passage of his essay he speaks of sea-water as "an alkaline fluid which does not contain the smallest trace of free carbonic acid."

Photometry.—M. J. Janssen attaches importance to the application of photography to photometric measurements. It not only permits the registration of all the visible rays, but also reaches the ultra-violet rays, and is competent to give valuable ideas relative to the temperature of bodies. While ordinary photometric comparisons between two sources of light are essentially fugitive, and require the simultaneous presence of both bodies, photography furnishes permanent terms of comparison which we may bring to bear whenever we will, and may even bequeath to the future. The relative photogenic intensities of two different sources may be easily ascertained by causing them to act in succession on two similar plates. Comparisons of the photographic power of the sun and a star may be made directly, but it is necessary to obtain an image of the star of perceptible dimensions; this may be done by putting the plate on which the image is to be received out of focus, so that the rays from the star, instead of falling upon a point, shall form a small circle of light.

Disinfection of Alcohol.—M. Naudine recently described to the Chemical Society of Paris a method which he had discovered for relieving alcohol of the bad taste it often acquires from the substances from which it

is distilled. This spirit, as prepared from various grains, fruits, beet-roots, etc., is produced in many qualities, each of which acquires some special and relatively disagreeable flavor from whatever article has been subjected to distillation; and the alcohols are therefore classified in the arts according to the sources from which they are derived, and subdivided into those of "good taste," "middling taste, and "bad taste." Other alcohols are found along with the vinous alcohol in fermentation, but, as a rule, they do not materially affect its taste. The case is different with the aldehydic or acetonic bodies that are produced, whose pronounced and disagreeable taste is obstinately persistent in rectification. The methods which have hitherto been employed to take away these tastes depend on oxidation; this acts, however, upon the alcohol itself, and generates odorous ethereal substances which only give another bad taste instead of the original one. No better results have been obtained with other substances that have been recommended, including potash, soda, oil, fat, soap, and sodium. M. Naudine has adopted a course which has been suggested by the fact that hydrogen, in a nascent state, converts the acetones into secondary alcohols. His method consists in the subjection of the alcohol to be purified to the action of the Gladstone and Triber reducing pile, or a similar battery, whereby hydrogen is developed and acts immediately upon the impurities of the spirit.

Speed of Explosives.—M. Berthelot has been investigating the speed with which explosive phenomena are propagated in gases. For this purpose, he filled with the explosive mixture of oxygen and hydrogen, carbonic oxide, and oxygen under atmospheric pressure, an iron tube about sixteen inches long and a third of an inch in bore, so arranged that the passage of an explosive could be accurately registered at a point close to where the spark was applied, at the middle, and at the farther end of the tube. The experiment showed the speed of propagation to be about twenty-five hundred metres (8,125 feet) a second. The results should not be regarded as furnishing the absolute value of the speed of the explosive force, for the quantities measured are too small for that; but they at least give an indication that the speed is much greater than had been supposed. Bunsen, for example, in 1867, had estimated it at thirty-four metres a second for detonating gas, and one metre for carbonic oxide mixed with oxygen. The rapid propagation of explosive phenomena appears to be due to the transmission of the successive shocks of the gaseous molecules, which have been brought into a vibratory condition more intense than the heat disengaged in their combination. The phenomena of explosion are, then, more complex than a simple movement of transmission, or even than the propagation of a sonorous wave.

Fossilized Standing Trees.—M. Fayol has observed fossilized trees standing perpendicular to the planes of stratification of the beds that contain them, in the coal-measures of Commentry. In the bed of Roseaux the trunks are so numerous as to resemble a fossil forest. The standing trees are fragments of trunks, without branches or roots, and occur generally in the grits, occasionally in the conglomerates, rarely in the shales, but not in the coal-beds. Prostrate trees are numerous in the shales, less abundant in the grits, and rare in the conglomerates, while numerous traces of them may be distinguished in certain parts of the coal-beds. The prostrate trees are a hundred times more numerous than the standing ones, and are found almost everywhere in the beds. These facts may be explained as the results of a transporting movement. A recently pulled-up plant, when thrown in the water, stands vertically, then sinks to the bottom in the same position, and afterward falls prostrate, remaining in each position for some hours or even days. If the trees were carried by the current to a lake or estuary, they would, according to the condition they were in, either float around for a while or sink at once, and would become fossilized in the position they took.

Disinfecting Powers of Sulphurous Acid.—Dr. Victor Fatio, of Geneva, has made a series of interesting experiments on the disinfecting power of sulphurous acid, particularly with reference to the destruction

of the phylloxera and its eggs. From them he has found that the application of the acid, in the proportion of fifty cubic centimetres of the liquid acid to one cubic metre of air, is sufficient to kill all the phylloxera and eggs in a closed box in two hours; that the same effects may be obtained immediately in the open air by sprinkling the box with fifty cubic centimetres of the acid to one square metre of surface; that confinement for a few minutes with the former proportion of acid is sufficient to kill the phylloxera and soft insects of an analogous nature and their eggs, and purely herbaceous plants, while dry seeds exposed to it retain their germinative powers; and that its application is equally efficacious against the parasites in museums, while it does not harm the specimens which they infest. Plants and insects of a moist texture are the more readily affected by the acid. A high temperature is favorable to the operation by promoting the diffusion of the acid gas; a moist atmosphere is against it, by its tendency to hold the gas in solution. The application of the anhydrous acid has advantages over that of burning sulphur in that it can be made where sulphur can not be burned, is safer, and more convenient.

NOTES.

THE President of the Entomological Section of the American Association stated, in his address at the meeting of the section, that while there were not known to be more than ten or twelve working entomologists in the country forty years ago, four hundred and thirty-six names were reported in last year's "Naturalists' Directory" of persons designated as entomologists. No other distinct branch of natural history except geology and botany has so many representatives in that book. The various journals of the last year contained three hundred and thirty-six contributions to entomology exclusively by Americans, the work of eighty writers.

THE appointment of M. Wurtz, President of the Academy of Science, to be life-Senator, raises the number of members of the Academy belonging to the Upper House of the French Legislature to three, the two other members being M. Robin and M. Dupuy de Lorne. The election of M. Berthelot, which is considered certain, will give the Academy a fourth representative in this body.

MR. F. W. PUTNAM has exhibited to the Boston Society of Natural History specimens of a collection of several hundred rude stone implements which Mr. David Dodge has obtained from plowed gravelly fields at Wakefield, Massachusetts. The implements had not yet been found in place in the gravel, so that it was not possible to decide that they were true palæolithic implements; for rude forms of the same character are often associated in this country with finely polished implements of the Neolithic period. Some of the specimens were obtained from a very old pile of stone-chips nearly buried in the side of a hill, where similar implements to those found in the fields near by had evidently been made. It was worthy of remark that none of the arrow-heads and similar forms, common near places where palæolithic objects have been discovered, had been found in connection with these implements.

IN a pamphlet on "The Discipline of the School," published by the Bureau of Education, Dr. Hiram Orcutt gives as the elements of school discipline, each of which he discusses under its special head: thorough organization and classification; the establishment of the authority of the teacher; work; a sound public opinion in the school; mental and physical recreation (gymnastics and exercise); kindness; power to punish, with wise discrimination, and courage to inflict punishment when it is required; regular systematic study and recitation; and good manners, which are inseparable from good morals.

PROFESSOR CYRUS THOMAS has made a study of the Mexican manuscript called the "Manuscript Troano," which was discovered by the Abbé Brasseur de Bourbourg in 1865, and has concluded that it is a genuine Maya document; that it is a religious calendar of some kind, in which the day-characters are used for the purpose of designating the days and not for the signification of the words; and that it confirms the substantial correctness of Landa's characters for the day. He has begun the attempt to decipher the hieroglyphics of the text.

THE yucca seldom perfects its seed in the United States. The failure is believed by Professor Riley to be in consequence of the flower depending for its pollination upon the office of an insect which has not yet been introduced to an extent corresponding with the diffusion of the plant. In his paper on "The Pollination of Yucca," before the American Association, Professor Riley describes some insects which he has found in or about the plant, by the agency of one or more of which he thinks the pollination may be accomplished in the rare cases where it is observed to occur.

THE experiments instituted by M. Pictet to determine the density of liquid oxygen, hydrogen, and nitrogen, have been followed up by Messrs. Cailletet and Hautefeuille, who have facilitated the processes by previously mixing the gases with carbonic acid and protoxide of nitrogen, whereby the liquefaction is made to take place more readily. The density of the liquids of the latter gases being known, it is easy to compute that of the substances under examination. The results of tests made at a very low temperature are favorable to the theory of the relations that have been suggested between hydrogen and magnesium, oxygen and sulphur, nitrogen and phosphorus; but, as the freezing-point of water is approached, discrepancies are manifested which grow more and more accentuated.

DR. LUTON, of Rheims, reports that he has discovered that the tincture of ergot of rye associated with phosphate of soda produces on those to whom it is administered an hilarious excitement, similar to that which is brought on by laughing-gas.

M. LENZ, in a communication made recently to the French Geographical Society, on his journey to Timbuctoo, says that in the Inguidi, a region of sand-dunes, he observed the equally rare and interesting phenomenon of resounding or musical sand. "All at once," he said, "there was heard in the desert, issuing from a dune of sand, a prolonged, muffled sound, quite like the sound of a trumpet. It continued for some seconds, then ceased, to be resumed in another direction. The phenomenon made the traveler anxious. I suppose it was occasioned by the friction upon each other of the burning grains of quartz, which are simply placed one by the other, and are continually in motion."

M. C. WIDEMAN has shown that the electrical qualities which are already plainly perceptible in most kinds of paper can be greatly increased by subjecting it to a previous treatment. Common unsized paper, Swedish filtering paper, or silk paper, when dipped in a mixture of equal volumes of nitric and sulphuric acids, washed and dried, becomes imperfectly transformed into pyroxile, and extremely electric. When put on a wooden table or an oil-cloth, and rubbed with the hand, it will immediately attract light bodies; if taken up from the oil-cloth in the dark, the whole surface shines like phosphorus; when the finger is brought toward it, it gives off a spark. A Leyden-jar may be charged with it. It gives off, when rubbed, the characteristic odor of ozone. It preserves its properties for a long time, and may have them restored by heating it. Thus, for a few cents, we may possess a machine competent to aid in the illustration of all electrical phenomena.

PROFESSOR LEBOUR, of Newcastle, in a paper on the geological distribution of endemic goitre in England, has shown that the conditions of the prevalence of this disease are substantially the same as they have been shown by the researches of Dr. de St. Lager, of Lyons, to be in France. In both countries the formations in which the most goitre is supported are both calcareous and metalliferous. Metalliferous impurities alone do not promote the disease, for the Devonian and granitic formations are free from it. The absence of limestone alone does not prevent it, for it exists on the lignitiferous beds of France, and the ferruginous sands of the weald. Dr. de St. Lager believes that endemic goitre coincides with metalliferous deposits, of which iron pyrites is most active.

PROFESSOR COPE, describing the *Canidæ* of the Loup Fork, or highest Miocene formation of the West, represents that the number of species is not so great as in the preceding periods of the Miocene, while those that are known more nearly approach the existing dogs in character, and are of a larger average size.

DR. J. YOUNG and Professor G. Forbes have made some new researches to measure the velocity of light, by the method that was employed by M. Fizeau and M. Cornu. The electric light was used, with two reflectors a quarter of a mile apart, and a revolving toothed wheel was employed to alter the intensity of the reflected light. Through this two stars of light were seen, one increasing, the other diminishing in intensity as the speed of the wheel was increased. The speed required to produce equality of the light was determined by means of a chronograph. The final result of the mean of the several observations for the velocity of the light from an electric lamp *in vacuo* was 187·273 miles a second. The observations on the color of the stars indicated that the blue rays travel faster than red rays, with a difference equivalent to about 1·8 per cent. of the whole velocity.

PROFESSOR RAOUL PICTET, of Geneva, announces the discovery of a method of construction for greatly increasing the speed of vessels by making such an arrangement of the keel as will diminish the resistance of the water to the lowest point. Where it is applied, the prow, instead of sinking deeper as the speed increases, will be raised, and only the sides of the hull and the neighborhood of the wheel will be exposed to the friction, so that the vessel will glide over the water instead of having to push its way through it. Professor Pictet expects to attain a speed of from thirty to thirty-six miles an hour. A vessel embodying his plans is building for Lake Leman.

DR. HANICHI MURAOKA, a Japanese student at Strasburg, has recently determined experimentally the specific resistance and the change of resistance to the galvanic current at all temperatures shown by all the kinds of hard carbon, including some artificial carbons and graphites. The highest specific resistance, at the freezing-point, was given by the graphitic compound used in Faber's lead-pencils, 952·0, and the lowest by Siberian graphite, 12·2, while the resistance of the artificial carbons prepared for electric lighting ranged from 36·86 to 55·15. The resistance in all the carbons decreased with a rise in temperature, the coefficient of decrease being greatest for Siberian graphite, the least for a carbon pencil prepared from coke. The thermo-electric force of all the samples was found to be *plus* to that of graphite.

M. DE LESSEPS states that the latest examinations of the *chotts* of Algeria and Tunis have shown that no serious difficulty need be apprehended in digging the projected canal which is intended to transform the marshy and unhealthy lowlands of the southern parts of those states into an interior sea. The ridge (*seuil*) of Gerbes is almost wholly formed of sands and siliceous or argillaceous marls, instead of being a mass of hard rocks, as some geologists have asserted.

M. JANSSEN is of the opinion that while it is easy enough to obtain a photographic image of the brighter parts of nebulæ, it must be extremely difficult to secure such complete images as will permit of their being used as an accurate standard with which to compare future observations. A nebula has no regular outline like the stars, but presents the appearance of flecks of cloud or haze, with indefinite borders and most diverse degrees of luminosity. The character of its photographic image will be modified by several circumstances, atmospheric conditions, instrumental power, sensibility of the plate, length of exposure, which can never be exactly repeated. Hence, two images of it will almost of necessity be different, though it may not have changed.

MR. MACKENDRICK has made a study of the coloring-matter of the *Medusæ*, and has succeeded in extracting some of it. The matter was shown under a microscope having a power of twelve hundred, in the form of little irregular particles of a diameter of one thirty-thousandth of an inch included in the colorless protoplasm of the small cells. When extracted it proved to be soluble in acids, but insoluble in alkalies. The coloring particles appear as granulations in the neutral tissues of the living medusa, but are dissolved and scattered after death as the tissues become acid.

THE technical school which was opened last fall, under the direction of the Metropolitan Museum of Art, had a very successful career during the winter, and was attended by one hundred and forty-three pupils. This fall, the art classes having been removed to new quarters, the building at First Avenue and Sixty-eighth Street will be occupied wholly by the trade-schools, which were to be opened on the 21st of November. It is the purpose of these schools to make thorough, efficient, and practical mechanics, who can earn a living by their trade. They will have departments of plumbing and sanitary engineering; house, sign, and decorative painting, with special courses in mixing colors, fresco-painting, and polishing in hard wood; and the science and practice of brick-laying. Practical instruction will be given by mechanics skilled in the different branches of their trades. The charges will cover the actual cost of instruction and of the materials used.

IN a paper on "The White Pine and the Lumber Industry of Michigan," Mr. W. H. Ballou shows that the quantity of pine timber in that State has decreased from 135,000,000,000 feet on 20,000,000 acres of land to 35,000,000,000 feet on 10,571,000 acres. Some 5,000,000,000 feet are now annually taken away, so that in seven years the supply will be exhausted. It almost seems a despairing task to hope ever to raise forests for another such enormous production, and science will have to devise other materials as a substitute for wood. Lumber is already made in boards an inch thick from wheat-straw, and can be colored so as accurately to resemble any real lumber. The inventor manufactures two thousand square feet of a more durable and cheaper material than lumber from a ton of straw.

MANY birds, according to Mr. E. E. Fish, appear to possess powers of ventriloquism. A cuckoo, not a rod off, can make his voice appear to come from a furlong away; the thrush, singing from a low perch, seems to be in the tree-tops; the vesper-sparrow and field-sparrow on the road-side fence, as if singing from a distant field. The robin has a similar power of throwing its voice, and the cat-bird can sing in a loud, voluble sound or in a low, soft, sweet, and tender warble. The oven-bird, the smallest of the thrushes, singing from a distance, can throw its sharp, ringing notes in such a way as to cause the listener to believe that it is almost within reach.

MR. W. H. M. CHRISTIE, F. R. S., first assistant at Greenwich Observatory, has been appointed Astronomer Royal to succeed Sir George Airy.

HENRI-ÉTIENNE SAINTE-CLAIRE DEVILLE.